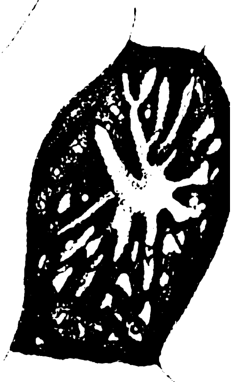
Fig IXa

Fig X

Fig XI



Journal and Proceedings of the Royal Society of New South ...

Royal Society of New South Wales

JOURNAL

AND

PROCEEDINGS

OF THE

ROYAL SOCIETY

OF

NEW SOUTH WALES,

1876.

VOL. X.

EDITED BY

A. LIVERSIDGE,

Professor of Geology and Mineralogy in the University of Sydney.

THE AUTHORS OF PAPERS ARE ALONE RESPONSIBLE FOR THE STATEMENTS MADE AND THE OPINIONS EXPRESSED THEREIN.

AGENTS FOR THE SOCIETY:

Messrs. Trübner & Co., 57, Ludgate Hill, London, E.C.

SYDNEY: CHARLES POTTER, ACTING GOVERNMENT PRINTER.

1877.

Entered, July 6, 1901.

66712

RULES AND LIST OF MEMBERS

OF THE

ROYAL SOCIETY

OF

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1877.

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1877.

3r 9—77

NOTICE.

It is requested that all Communications respecting the Printing of the Journal of the Society, or List of Members, may be sent to Professor Liversidge (Editor), Union Club, Sydney.

All Donations presented to the Society are acknowledged by letter, and in the printed Proceedings of the Society.

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1877.

NOTICE.

MEMBERS of the Royal Society of New South Wales are informed that the Library will be open for consultation, and for the issue of books, on Wednesday afternoons from 4 to 6 p.m., and on the evenings of Monday, Wednesday, and Friday, from 7 to 10 p.m. during the session, except on the afternoon of the last, and the evening of the first Wednesday in each month.

PUBLICATIONS.

Certain of the following publications of the Society can now be obtained at the Society's Rooms in Elizabeth-street :—

Transactions of the Philosophical Society of N.S.W., 1862–6, price, 10s. 6d.

Transactions	of the	Royal	Society,	N.S.W.,	1867,	out of print.
,,	,,	,,	,,	,,	1868,	,,
,,	,,	,,	,,	,,	1869,	price 5s.
,,	,,	,,	,,	,,	1870,	,, 5s.
,,	,,	,,	,,	,,	1871,	,, 5s.
,,	,,	,,	,,	,,	1872,	,, 5s.
,,	,,	,,	,,	,,	1873,	,, 5s.
,,	,,	,,	,,	,,	1874,	out of print.
Transactions and Proceedings,				,,	1875,	price 7s. 6d.
Journal	,,	,,	,,	,,	1876,	,, 10s. 6d.

NOTICE.

THE ROYAL SOCIETY of New South Wales originated in 1821 as the "Philosophical Society of Australia"; after an interval of inactivity, it was resuscitated in 1850, under the name of the "Australian Philosophical Society," by which title it was known until 1856, when the name was changed to the "Philosophical Society of New South Wales"; and finally, in May, 1866, by the sanction of Her Most Gracious Majesty the Queen, it assumed its present title.

CORRIGENDA.

Page.	*Line.*	
12	1	For "Deputy Governor" *read* "Lieutenant Governor."
235	27	For "lower strata, and this" *read* "lower strata. This meets, etc."

CONTENTS.

VOLUME X.

The Royal Society of New South Wales.

OFFICERS FOR 1876–7.

PRESIDENT:

HIS EXCELLENCY SIR HERCULES ROBINSON, K.C.M.G.,
&c., &c., &c.

VICE-PRESIDENTS:

REV. W. B. CLARKE, M.A., F.R.S., F.G.S.
ROLLESTON, CHRISTOPHER.

HONORARY TREASURER:

REV. W. SCOTT, M.A.

HONORARY SECRETARIES:

PROFESSOR LIVERSIDGE. | DR. ADOLPH LEIBIUS.

COUNCIL:

FAIRFAX, JAMES R.
JONES, P. SYDNEY, M.D.
MOORE, CHARLES, F.L.S.
RUSSELL, H. C., B.A., F.R.A.S.
SMITH, HON. J., C.M.G., M.D.
WRIGHT, H. G. A., M.R.C.S.

ASSISTANT SECRETARY:

WEBB, W. H.

FUNDAMENTAL RULES.

Object of the Society.

1. The object of the Society is to receive at its stated meetings original papers on subjects of Science, Art, Literature, and Philosophy, and especially on such subjects as tend to develop the resources of Australia, and to illustrate its Natural History and Productions.

President.

2. The Governor of New South Wales shall be *ex officio* the President of the Society.

Other Officers.

3. The other Officers of the Society shall consist of two Vice-Presidents, a Treasurer, and two or more Secretaries, who, with six other Members, shall constitute a Council for the management of the affairs of the Society.

Election of Officers.

4. The Vice-Presidents, Treasurer, Secretaries, and the six other Members of Council, shall be elected annually at the General Meeting in the month of May.

Vacancies during the year.

5. Any vacancies occurring in the Council of Management during the year may be filled up by the Council.

Fees.

6. The entrance money paid by Members on their admission shall be One Guinea; and the annual subscription shall be One Guinea, payable in advance.

The sum of Ten Pounds may be paid at any time as a composition for the ordinary annual payment for life.

Honorary Members.

7. The Honorary Members of the Society shall be persons who have been eminent benefactors to this or some other of the Australian Colonies, or distinguished patrons and promoters of the objects of the Society. Every person proposed as an Honorary Member must be recommended by the Council and elected by the Society. Honorary Members shall be exempted from payment of fees and contributions; they may attend the meetings of the Society, and they shall be furnished with copies of Transactions and Proceedings published by the Society, but they shall have no right to hold office, to vote, or otherwise interfere in the business of the Society.

Confirmation of By-laws.

8. By-laws proposed by the Council of Management shall not be binding until ratified by a General Meeting.

Alteration of Fundamental Rules.

9. No alteration of or addition to the Fundamental Rules of the Society shall be made unless carried at two successive general meetings.

BY-LAWS

Passed at a General Meeting of the Society, held June 7th, 1876.

Ordinary General Meetings.

I. An Ordinary General Meeting of the Royal Society, to be convened by public advertisement, shall take place at 8 p.m., on the first Wednesday in every month, during the last eight months of the year; subject to alteration by the Council with due notice. These meetings will be open for the reading of papers, and the discussion of subjects of every kind if brought forward in conformity with the Fundamental Rules and By-laws of the Society.

Annual General Meeting.—Annual Reports.—Election of Officers.

II. A General Meeting of the Society shall be held annually in May, to receive a Report from the Council on the state of the Society, and to elect Officers for the ensuing year. The Treasurer shall also at this meeting present the annual financial statement.

Election of the Officers and Council.

III. The Officers and other members of the Council shall be elected annually *by ballot* at the Annual General Meeting to be held in May.

IV. It shall be the duty of the Council each year to prepare a list containing the names of members whom they recommend for election to the respective offices of Vice-Presidents and Hon. Secretaries and Hon. Treasurer, together with the names of six other members whom they recommend for election as ordinary members of Council. The names thus recommended shall be proposed at one meeting of the Council, and agreed to at a subsequent meeting.

V. Each member present at the General Annual Meeting shall have the power to alter the list of names recommended by the Council, by adding to it the names of any eligible members not already included in it and removing from it an equivalent number of names, and he shall use this list with or without such alterations as a balloting list at the election of Officers and Council.

Council Meetings.

VI. Meetings of the Council of Management shall take place on the last Wednesday in every month, and on such other days as the Council may determine.

Absence from Meetings of Council.—Quorum.

VII. Any member of the Council absenting himself from three consecutive meetings of the Council, without giving a satisfactory explanation in writing, shall be considered to have vacated his office, and the election of a member to fill his place shall be proceeded with at the next Council meeting in accordance with Fundamental Rule V. No business shall be transacted at any meeting of the Council unless three members are present.

Duties of Secretaries.

VIII. The Honorary Secretaries shall perform, or shall cause the Assistant Secretary to perform, the following duties :—

1. Conduct the correspondence of the Society and Council.
2. Attend the General Meetings of the Society and the meetings of the Council, to take minutes of the proceedings of such meetings, and at the commencement of such to read aloud the minutes of the preceding meeting.
3. At the Ordinary Meetings of the members, to announce the presents made to the Society since their last meeting; to read the certificates of candidates for admission to the Society, and such original papers communicated to the Society as are not read by their respective authors, and the letters addressed to it.

4. To make abstracts of the papers read at the Ordinary General Meetings, to be inserted in the Minutes and printed in the Proceedings.
5. To edit the Transactions of the Society, and to superintend the making of an Index for the same.
6. To be responsible for the arrangement and safe custody of the books, maps, plans, specimens, and other property of the Society.
7. To make an entry of all books, maps, plans, pamphlets, &c., in the Library Catalogue, and of all presentations to the Society in the Donation Book.
8. To keep an account of the issue and return of books, &c., borrowed by members of the Society, and to see that the borrower, in every case, signs for the same in the Library Book.
9. To address to every person elected into the Society a printed copy of the Forms Nos. 2 and 3 (in the Appendix), together with a list of the members, a copy of the Fundamental Rules and By-laws, and a card of the dates of meeting; and to acknowledge all donations made to the Society, by Form No. 5.
10. To cause due notice to be given of all Meetings of the Society and Council.
11. To be in attendance at 4 p.m. on the afternoon of Wednesday in each week during the session.
12. To keep a list of the attendances of the members of the Council at the Council Meetings and at the Ordinary General Meetings of the members of the Society, in order that the same may be laid before the Society at the Annual General Meeting held in the month of May.

The Honorary Secretaries shall, by mutual agreement, divide the performance of the duties above enumerated.

The Honorary Secretaries shall, by virtue of their office, be members of all Committees appointed by the Council.

Candidates for admission.

IX. Every candidate for admission as an ordinary member of the Society shall be recommended according to a prescribed form, by not less than three members, to two of whom he must be personally known.

Election of new Members.

X. The names of such candidates, with the names of their supporters, shall be read by one of the Secretaries at an Ordinary General Meeting of the Society. The vote as to admission to take place by ballot at the next subsequent meeting. At the ballot the assent of at least four-fifths of the members voting shall be requisite for the admission of the candidate.

New Members to be informed of their election.

XI. Every new member shall receive due notification of his election, and be supplied with a copy of the obligation (No. 3 in Appendix), together with a copy of the Fundamental Rules and By-laws of the Society, a list of members, and a card of the dates of meeting.

Members whose subscriptions are unpaid to enjoy no privileges.

XII. An elected member shall not be entitled to attend the meetings nor to enjoy any privilege of the Society, nor shall his name be printed in the list of the Society, until he shall have paid his admission fee and first annual subscription, and have returned to the Secretaries the obligations signed by himself.

Members shall sign Rules—Formal admission.

XIII. Every member who has complied with the preceding By-laws shall at the first Ordinary General Meeting at which he shall be present, sign a duplicate of the aforesaid obligation in a book to be kept for that purpose, after which he shall be presented by some member to the Chairman, who, addressing him by name, shall say :—"By the authority and in the name of the Royal Society of New South Wales I admit you a member thereof."

Annual subscriptions, when due.

XIV. Annual subscriptions shall become due on the 1st of May for the year then commencing. The entrance fee and first year's subscription of a new member shall become due on the day of his election.

Subscriptions in arrears.

XV. Members who have not paid their subscriptions for the current year, on or before the 31st of May, shall be informed of the fact by the Hon. Treasurer.

And at the meeting held in July, and at all subsequent meetings for the year, a list of the names of all those members who are in arrears with their annual subscriptions shall be suspended in the Rooms of the Society. Members shall in such cases be informed that their names have been thus posted.

Resignation of Members.

XVI. No member shall be at liberty to withdraw from the Society without previously giving notice to one of the Secretaries of his desire to withdraw, and returning all books or other property belonging to the Society. Members will be considered liable for the payment of all subscriptions due from them up to the date at which they may give notice of their intention to withdraw from the Society.

Expulsion of Members.

XVII. A majority of members present at any ordinary meeting shall have power to expel an obnoxious member from the Society, provided that a resolution to that effect has been moved and seconded at the previous ordinary meeting, and that due notice of the same has been sent in writing to the member in question, within a week after the meeting at which such resolution has been brought forward.

Contributions to the Society.

XVIII. Contributions to the Society, of whatever character, must be sent to one of the Secretaries, to be laid before the

Council of Management. It will be the duty of the Council to arrange for promulgation and discussion at an Ordinary Meeting such communications as are suitable for that purpose, as well as to dispose of the whole in the manner best adapted to promote the objects of the Society.

Order of Business.

XIX. At the Ordinary General Meetings the business shall be transacted in the following order, unless the Chairman specially decide otherwise:—

1—Minutes of the preceding Meeting.
2—New Members to enrol their names and be introduced.
3—Ballot for the election of new Members.
4—Candidates for membership to be proposed.
5—Business arising out of Minutes.
6—Communications from the Council.
7—Communications from the Sections.
8—Donations to be laid on the Table and acknowledged.
9—Correspondence to be read.
10—Motions from last Meeting.
11—Notices of Motion for the next Meeting to be given in.
12—Papers to be read.
13—Discussion.
14—Notice of Papers for the next Meeting.

Admission of Visitors.

XX. Every ordinary member shall have the privilege of admitting two friends as visitors to an Ordinary General Meeting of the Society, on the following conditions:—

1. That the name and residence of the visitors, together with the name of the member introducing them, be entered in a book at the time.
2. That they shall not have attended two consecutive meetings of the Society in the current year.

The Council shall have power to introduce visitors, irrespective of the above restrictions.

Management of Funds.

XXI. The funds of the Society shall be lodged at a Bank named by the Council of Management. Claims against the Society, when approved by the Council, shall be paid by the Treasurer.

Money Grants.

XXII. Grants of money in aid of scientific purposes from the funds of the Society—to Sections or to members—shall expire on the 1st of November in each year. Such grants, if not expended, may be re-voted.

XXIII. Such grants of money to Committees and individual members shall not be used to defray any personal expenses which a member may incur.

Audit of Accounts.

XXIV. Two Auditors shall be appointed annually, at an Ordinary Meeting, to audit the Treasurer's Accounts. The accounts as audited to be laid before the Annual Meeting in May.

Property of the Society to be vested in the Vice-Presidents, &c.

XXV. All property whatever belonging to the Society shall be vested in the Vice-Presidents, Hon. Treasurer, and Hon. Secretaries for the time being, in trust for the use of the Society; but the Council shall have control over the disbursements of the funds and the management of the property of the Society.

Library.

XXVI. The Members of the Society shall have access to, and shall be entitled to borrow books from the Library, under such regulations as the Council may think necessary.

Museum.

XXVII. It shall be one of the objects of the Society to form a Museum.

Branch Societies.

XXVIII. The Society shall have power to form Branch Societies in other parts of the Colony.

SECTIONS.

XXIX. To allow those members of the Society who devote attention to particular branches of science fuller opportunities and facilities of meeting and working together with fewer formal restrictions than are necessary at the general Monthly Meetings of the Society,—Sections or Committees may be established in the following branches of science:—

Section A.—Astronomy, Meteorology, Physics, Mathematics, and Mechanics.

Section B.—Chemistry and Mineralogy, and their application to the Arts and Agriculture.

Section C.—Geology and Palæontology.

Section D.—Biology, *i.e.*, Botany and Zoology, including Entomology.

Section E.—Microscopical Science.

Section F.—Geography and Ethnology.

Section G.—Literature and the Fine Arts, including Architecture.

Section H.—Medical.

Section I.—Sanitary and Social Science and Statistics.

Reports from Sections.

XXX. There shall be for each Section a Chairman to preside at the meetings, and a Secretary to keep minutes of the proceedings, who shall jointly prepare and forward to the Hon. Secretaries of the Society, on or before the 7th of November in each year, a report of the proceedings of the Section during that year, in order that the same may be transmitted to the Council.

Section Committees—Card of Meetings.

XXXI. The first meeting of each Section shall be appointed by the Council. At that meeting the members shall elect their own Chairman, Secretary, and a Committee of four; and arrange the days and hours of their future meetings. A card showing the dates of each meeting for the current year shall be printed for distribution amongst the members of the Society.

Money Grants to Sections.

XXXII. By application to the Council, grants of money may be made out of the General Funds of the Society to the Sections.

Membership of Sections.

XXXIII. No person who is not a member of the Society shall have the privilege of joining any of the Sections.

Form No. 1.

ROYAL SOCIETY OF NEW SOUTH WALES.

Certificate of a Candidate for Election.

Name

Qualification or occupation

Address

being desirous of admission into the Royal Society of New South Wales, we, the undersigned members of the Society, propose and recommend him as a proper person to become a member thereof.

Dated this day of , 18 .

FROM PERSONAL KNOWLEDGE.	FROM GENERAL KNOWLEDGE.

Signature of candidate

Date received 18 .

Form No. 2.

ROYAL SOCIETY OF NEW SOUTH WALES.

The Society's Rooms,

Sir, Sydney, 18 .

I have the honor to inform you that you have this day been elected a member of the Royal Society of New South Wales, and I beg to forward to you a copy of the Fundamental Rules and By-laws of the Society, a printed copy of an obligation, a list of members, and a card announcing the dates of meeting during the present session.

According to the Regulations of the Society (*vide* Rule No. 6), you are required to pay your admission fee of one guinea, and annual subscription of one guinea for the current year, before admission. You are also requested to sign and return the enclosed form of obligation at your earliest convenience.

I have honor to be,

Sir,

Your most obedient servant,

To Hon. Secretary.

Form No. 3.

ROYAL SOCIETY OF NEW SOUTH WALES.

I, the undersigned, do hereby engage that I will endeavour to promote the interests and welfare of the Royal Society of New South Wales, and to observe its Rules and By-laws as long as I shall remain a member thereof.

Signed,

Address

Date

Form No. 4.

ROYAL SOCIETY OF NEW SOUTH WALES.

The Society's Rooms,

Sir, Sydney, 18 .

I have the honor to inform you that your annual subscription of one guinea for the current year became due to the Royal Society on the 1st of May last.

It is requested that payment may be made by cheque or Post Office order drawn in favour of the Hon. Treasurer.

I have the honor to be,

Sir,

Your most obedient servant,

To Hon. Treasurer.

Form No. 5.

ROYAL SOCIETY OF NEW SOUTH WALES.

The Society's Rooms,

Sir, Sydney, 18 .

I am desired by the Royal Society of New South Wales to forward to you a copy of its Journal for the year 18 , as a donation to the library of your Society.

I am further requested to mention that the Society will be thankful to receive such of the very valuable publications issued by your Society as it may feel disposed to send.

I have the honor to be,

Sir,

Your most obedient servant,

Hon. Secretary.

Form No. 6.

ROYAL SOCIETY OF NEW SOUTH WALES.

The Society's Rooms,

Sir, Sydney, 18 .

On behalf of the Royal Society of New South Wales, I beg to acknowledge the receipt of and I am directed to convey to you the best thanks of the Society for your most valuable donation.

I have the honor to be,

Sir,

Your most obedient servant,

Hon. Secretary.

Form No. 7.

Balloting List for the Election of the Officers and Council.

ROYAL SOCIETY OF NEW SOUTH WALES.

May, 18 .

If you wish to substitute any other name in place of that proposed, erase the printed name in the second column, and write opposite to it, in the third, that which you wish to substitute.

LIST OF THE MEMBERS

NOTICE.

Members are particularly requested to communicate any change of address to the Hon. Secretaries, for which purpose this slip is inserted.

Corrected Address.

Name ....

Titles, &c. ....

Address ....

....

Date ....

To the

Hon. Secretaries,

Royal Society of N. S. W.,

Elizabeth-st., Sydney.

		Bombala.
1875		Bartels, W. C. W., Union Club.
1876		Bassett, W. F., M.R.C.S., *Eng.*, Bathurst.
1875		Bedford, W. J. G., M.R.C.S. *Eng.*, Staff Surgeon.
1875		Belgrave, Thomas B., M.D. *Edin.*, M.R.C.S. *Eng.*, Liverpool-street.
1877		Belfield, Algernon H., Eyersleigh, Armidale.
1875		Belisario, John, M.D. Lyons' Terrace.
1876		Benbow, Clement A., 24, College-street.
1869	P 3	Bensusan, S. L., Exchange, Pitt-street.
1877		Bennett, John, Victoria Theatre, Sydney.

Elected.		
1871	P 1	Brazier, John, C.M.Z.S., 11, Windmill-street.
1868		Brereton, John Le Gay, M.D. *St. Andrew's*, L.R.C.S. *Edin.*, Macquarie-street.
1874		Brewster, John, George-street.
1876		Bristowe, E. H. C., 372, Crown-street, Sydney.
1876		Brodribb, W. A., Double Bay.
1876		Brown, Henry Joseph, Newcastle.
1876		Brown, Thomas, Eskbank, Bowenfels, and Australian Club.
1876		Burn, James Henry, Moncur-street, Woollahra.
1875		Busby, The Hon. William, M.L.C., Redleaf, South Head Road, near Woollahra.
1875		Burton, Edmund, Land Titles Office, Elizabeth-street North.
1876		Cadell, Alfred, Vegetable Creek, New England.
1876		Cadell, Thomas, Wotonga, East St. Leonards.
1876		Campbell, Allan, L.R.C.P., *Glasgow*, Yass.
1876		Campbell, The Hon. Alexander, M.L.C., Woollahra.
1868		Campbell, The Hon. Charles, M.L.C., Pine Villa, Newtown.
1872		Campbell, The Hon. John, M.L.C., Campbell's Wharf, Lower George-street.
1870		Cane, Alfred, Stanley-street.
1876		Chandler, Alfred, 185 Pitt-street.
1876		Christie, Wm., L.S., Hawthorn Lodge, Glen Innes.
1850	P 19	†Clarke, Rev. W. B., M.A. *Cantab.*, F.R.S., F.G.S., C.M.Z.S., F.R.G.S., Mem. Geol. Soc. France, Corres. Imp. Roy. Geol. Inst. Austria, Hon. Mem. N.Z. Inst. Cor. Mem. Roy. Soc. Tasmania, Fellow of St. Paul's College, *Vice-President*, Branthwaite, St. Leonards, North Shore.
1874		Clay, William French, M.A., *Cantab.*, M.D. *Syd.*, M.R.C.S. *Eng.*, Fellow of St. Paul's Col., North Shore.
1876		Clune, Michael Joseph, M.A.,Lic. K. & Q. Coll. Phys. *Irel.*, Lic. R. Coll. Sur. *Irel.*, 4, Hyde Park Terrace.
1876		Codrington, John Fredk., M.R.C.S., E.; Lic. R.C. Phys., L.; Lic. R.C. Phys., *Edin.*, Orange.
1876		Colyer, John Usher Cox, A.S.N. Company, Sydney.
1856		Comrie, James, Northfield, Kurrajong.
1876		Conder, Wm., Survey Office, Sydney.
1874		Coombes, Edward, Bathurst.
1859	P 2	Cox, James, M.D. *Edin.* C.M.Z.S., F.L.S., Hunter-street.
1865	P 2	Cracknell, E. C., Superintendent of Telegraphs, Telegraph Office, George-street.
1869		Creed, J. Mildred, M.R.C.S. *Eng.*, Scone.
1870		Croudace, Thomas, Lambton.
1873		Daintrey, Edwin, Æolia, Randwick.
1876		Dalgarno, John V., Telegraph Office, George-street.
1876		Dansey, George Frederick, M.R.C.S., London, York and Margaret Streets, Wynyard Square.
1874		Dansey, John, M.R.C.S. *Eng.*, Wynyard Square.
1875		Dangar, Frederick H., Greenknowes, Darlinghurst.
1876		Darley, Cecil West, Newcastle.
1876		Davidson, L. Gordon, M.D., M.C., *Aberdeen*, Goulburn.

Elected.		
1856		Deffell, George H., Clark's-street, Hunter's Hill.
1869		De Lissa, Alfred, Pitt-street.
1875		De Salis, The Hon. Leopold Fane, M.L.C., Union Club.
1875		De Salis, L. W. junr., Union Club.
1873		Dibbs, George R., M.P., 131, Pitt-street.
1876		Dight, Arthur, Richmond.
1876		Dixon Douglas, Australian Club.
1875		Dixon, W. A., F.C.S., Hunter-street.
1876		Docker, Ernest, M.A. *Sydn.*, Roslyn st., Macleay-street.
1876		Douglas James, L.R.C.S. *Edin.*, Hope Terrace, Glebe Road.
1876		Drake, William Hedley, Commercial Bank, Inverell.
1873		Du Faur, Eccleston, F.R.G.S., Rialto Terrace.
1874		Dumaresq, William A.
1875		Eagar, The Hon. Geoffrey, Colonial Treasury, Macquarie-street.
1876		Eales, John, Duckenfield Park, Morpeth.
1876		Egan Myles, M.R.C.S., *Eng.*, 2, Hyde Park Terrace, Liverpool-street.
1874		Eichler, Charles F., M.D., *Heidelberg*, M.R.C.S., *Eng.*, Bridge-street.
1876		Eldred, W. H., 119, Castlereagh-street.
1876		Evans, George, Como, Darling Point.
1876		Evans, Owen Spencer, M.R.C.S., *Eng.*, Darling-street, Balmain.
1868		Fairfax, The Hon. John, M.L.C., *Herald* Office, Hunter-street.
1868		Fairfax, James R., *Herald* Office, Hunter-street.
1872		Farnell, J. Squire, M.P., Ryde.
1874		Fischer, Carl F., M.D., F.L.S., Soc. Zool. Bot. Vindob. Socius., 251, Macquarie-street.
1876		Fisher, Chas. Marshall, 132, Pitt-street.
1876		Fitzgerald, R. D., F.L.S., Surveyor General's Office.
1856		Flavelle, John, George-street.
1863		Fortescue, G., M.B. *Lond.*, F.R.C.S., F.L.S., Lyons' Terrace.
1875		Frazer, Hon. John, M.L.C., Quirang, Woollahra.
1876		Frean Richard, M.R.C.S. *Eng.*, Sydney Infirmary.
1876		Freehill, Bernard Austin, 130, Elizabeth-street.
1876		Firth, Rev. Frank, Wesleyan Parsonage, Newcastle.
1876		Fyffe, Benjamin, M.R.C.S. *Eng.*, Castlereagh-street.
1868	P 1	Garran, Andrew, LL.D. *Syd.*, *Herald* Office, Hunter-street.
1876		George, W. R, 172, Castlereagh-street.
1876		Gilchrist, W. O., Elizabeth Bay.
1875		Gilliat, Henry Alfred, Australian Club.
1876		Gillman, Thomas Henry, B.A., C.M., M.D., Queen's Univ. *Irel.*, Mast. Surg. Queen's Univ. *Irel.*, 20, College-street.
1876		Gipps, F. B., Strathspey House, Macquarie-street.
1859		Goodlet, John H., George-street.
1868		Goodchap, Charles, Department of Public Works, Phillip-street.
1876		Goode, George, M.B. Univ. *Dub.*, B.A., M.C.L., Eversfield House, Camden.

Elected.		
1876		Graham, Hon. Wm., M.L.C., The Union Club, Sydney.
1873		Greaves, W. A. B., Armidale.
1875		Grundy, F. H., 183, Pitt-street.
1864		Hale, Thomas, Gresham-street.
1874		Hardy, J., Hunter-street.
1874		Hay, The Hon. John, M.A., *Glasgow*, M.L.C., President of the Legislative Council, Rose Bay, Woollahra.
1876		Hayley, William Foxton, M.R.C.S., *Eng.*, Goulburn.
1876		Heaton, J. H., *Town and Country* Office, Pitt-street.
1875		Helsham, Douglass, York's Terrace, Glebe.
1876		Heron, Henry, 4, Rialto Terrace, William-street South.
1859		‡Hill, Edward S., C.M.Z.S., Rose Bay, Woollahra.
1876	P 1	Hirst, Geo. D., 379, George-street.
1868		Holt, The Hon. Thomas, M.L.C., The Warren, near Sydney.
1876		Holroyd, Arther Todd, M.B. *Cantab.*, M.D. *Edin.*, F.L.S., F.Z.S., F.R.G.S., Master-in-Equity, Sherwood Scrubs, Parramatta.
1870	P 1	Horton, Rev. Thomas, Point Piper Road, Woollahra.
1876		Icely, Thos. R., Carcoar.
1876		Jackson, Henry William, L.R.C.S. *Edin.*, Lic. R. Phys., *Edin.*, 130, Phillip-street.
1876		Jarrett, Fredk. C., 292, George-street.
1876		Jenkins, Richard Lewis, M.R.C.S., Nepean Towers, Douglass Park.
1874		Jennings, P. A., Edgecliffe Road, Woollahra.
1876		Jones, James Aberdeen, Lic. R.C. Phys,. *Edin.*, Booth-street, Balmain.
1876		Jones, Richard Theophilus, M.D. *Sydn.*, L.R.C.P. *Edin.*, Ashfield.
1867		Jones, P. Sydney, M.D. *Lond.*, F.R.C.S. *Eng.*, College-street.
1874		Jones James, Bathurst-street.
1863		Josephson, Joshua Frey, F.G.S., District Court Judge, Enmore Road, Newtown.
1876		Josephson, J. P., 253, Macquarie-street North.
1873		Kater, Henry Herman, Burwood.
1876		Keele, Thos. Wm., Harbours and Rivers Department, Phillip-street.
1873		Kennedy, Hugh, B.A. *Oxon.* Registrar of the Sydney University, Enmore Road.
1874		King, Philip G., William-street, Double Bay.
1874		Knox, George, B.A., *Cantab.*, King-street.
1875		Knox, Edward, 24, Bridge-street.
1875		Lambert, G.P., M.R.C.S. *Eng.*, Phillip-street.
1867	P 3	Lang, Rev. John Dunmore, D.D., M.A. *Glasgow*, Jamison-street.
1876		Langley, W.E., *Herald* Office, Sydney.

Elected.		
1874	P 1	Latta, G. J., O'Connell-street.
1876		Laure, Louis Thos., M.D. Surg. Univ. *Paris*, 131, Castlereagh-street.
1859	P 5	†Leibius, Adolph, Ph. D. *Heidelberg*, Senior Assayer to the Sydney Branch of the Royal Mint, *Hon. Secretary*.
1874		Lenehan, Henry Alfred, Computer,, Sydney Observatory.
1872	P 8	†Liversidge, Archibald, F.C.S.; F.G.S.; Assoc. R. S. Mines, *Lond.;* Mem. Phy. Soc. London; Mem. Mineralogical Soc. Gt. Brit. and Irel.; Cor. Mem. Roy. Soc. Tas.; Cor. Mem. Senckenberg Institute, Frankfurt; Cor. Mem. Soc. d'Acclimat. Mauritius; Professor of Geology and Mineralogy in the University of Sydney, *Hon. Secretary*, Union Club.
1875		Living, John, Marsaloo, North Shore.
1874		Lloyd, George Alfred, M.P., F.R.G.S., O'Connell-street.
1876		†Lord, The Hon. Francis, M.L.C., North Shore.
1876		Lyons, W., M.R.C.S., *Eng.*, Wollongong.
1870		Macafee, Arthur H. C., York-street.
1859		MacDonnell, William, George-street.
1868		MacDonnell, William J., F.R.A.S., George-street.
1872		Mackenzie, John, F.G.S., Examiner of Coal Fields, Newcastle.
1874		Mackenzie, W. F., M.R.C.S., *Eng.*, Lyons' Terrace.
1876		Mackenzie, Rev. P. F., Paddington.
1876		Mackellar, Chas. Kinnard, M.B., C.M., *Glas.*, Lyons' Terrace.
1876		Maclaurin, Henry Norman, M.A., M.D. Univ., *Edin.*, Lic. R. Coll. Sur. *Edin.*, 187, Macquarie-street.
1873		Makin, G. E., Berrima.
1873	P 4	†Manning, James, Milsom's Point, North Shore
1876		Manning, Frederick Norton, M.D. Univ. *St. And.*, M.R.C.S., *Eng.*, Lic. Soc. Apoth. *Lond.*, Gladesville.
1869		Mansfield, G.A., Pitt-street.
1872		Marsden, The Right Rev. Dr., Bishop of Bathurst, Bathurst.
1876		Marshall, George, M.D. Univ. *Glas.*, Lic. R. Coll. S. *Edin.*, Lyons' Terrace.
1876		Martin, Rev. George, Newtown.
1876		Martin, John, Ryde.
1875		Mathews, R. H., Mundooran.
1876		M'Carthy, W. F., Deepdeen, Glenmore Road.
1876		M'Culloch, A. H., jun., 165, Pitt-street.
1874		M'Cutcheon, John Warner, Assayer to the Sydney Branch of the Royal Mint.
1876		M'Guire, W. H., Telegraph Office, George-street.
1876		M'Kay, Charles, M.D. Univ. *St. And.*, Lic. R. Coll. Surg. *Edin.*, Church Hill.
1868		Metcalfe, Michael, Bridge-street.
1873		Milford, F., M.D., *Heidelberg*, M.R.C.S. *Eng.*, College-street.
1876		Milford, Saml. Fredk. Tollett, M.R.C.S., E., M.B. Univ. *Heidelberg*, College-street.
1876		Millard, Rev. Henry Shaw, Newcastle Grammar School.
1875		Moir, James, Margaret-street.
1875		Montefiore, E. L., Macleay-street.
1876		Montefiore, George B., 5, Gresham-street.
1856	P 4	†Moore, Charles, F.L.S., Director of the Botanic Gardens, Botanic Gardens.

Elected.		
		Morehead, R. A. A., 30, O'Connell-street.
1865	P 1	Morrell, G. A., C.E., Department of Works, Phillip-street.
1872		Morgan, Cosby William, M.D. *Brussels*, L.R.C.P. *Lond.*, 1, Grosvenor Terrace, Church Hill.
1876		Morgan, Allan Bradley, M.R.C.S. *Eng.*, Lic. Mid. Lic. R. Coll. Phys. *Edin.*, Ashenhurst, Burwood.
1876		Morgan, Thos. Cecil, Lic. R.C.S., E., L.M.R.C.S., *Irel.*, Australian Club.
1865		Murnin, M. E., Exchange, Bridge-street.
1876		Murray, W. G., Macquarie-street.
1876		Myles, Chas. Henry, Wymela, Burwood.
1873		Neill, William, City Bank, Pitt-street.
1874		Neill, A. L. P., City Bank, Pitt-street.
1874		Nicol, D., Burwood.
1876		Nield, John Cash, M.D. & C.D., *Berlin*, M.R.C.S. *Eng.*, Lic. Soc. Apoth. *Lond.*, Elzabeth-street, Sydney.
1876		Nilson, Aroid, Department of Mines.
1873		Norton, James, Elizabeth-street.
1875		Nott, Thomas, M.D. *Aberdeen*, M.R.C.S. *Eng.*, Woollahra.
1875		O'Reilly, W. W. J., M.D., M.C., Q. Univ. *Irel.*, M.R.C.S., *Eng.*, Liverpool-street.
1875		Owen, The Hon. Robert, M.L.C., 88, Elizabeth-street.
1875		Palmer, J. H., Legislative Assembly.
1876		Parbury, Chas., Union Club.
1876		Parrott, Thomas S., Ashfield.
1861		Paterson, Hugh, Macquarie-street.
1874		Pedley, Frederick, Wynyard-square.
1872		Pendergast, Robert, Hay-street.
1875		Phillip, H., Pacific Insurance Company.
1876		Pickburn Thomas, M.D., *Aberdeen*, Ch. M., M.R.C.S., *Eng.*, 40, College-street.
1862		Prince, Henry, George-street.
1876		Quaife, Fredk. Harrison, M.D., Mast. Surg. Univ. *Glas.*, Piper-street, Woollahra.
1876		Quirk, Rev. Dr. J. A., O.S.B., LL.D., *Syd.*, Lyndhurst College.
1876		Quodling, W. H., Burwood.
1865	P 1	‡Ramsay, Edward, F.L.S., Curator of the Australian Museum, College-street.
1876		Ratte, F., Noumea, New Caledonia.
1874		Read, Reginald Bligh, M.R.C.S., *Eng.*, Randwick.
1868		Reading, E., Mem. Odont. Soc. *Lond.*, Castlereagh-street.

Elected.		
1876		Reece, J. D., Surveyor General's Office.
1870		Renwick, Arthur, M.D. *Edin.*, B.A., *Syd.*, F.R.C.S.E., 295, Elizabeth-street.
1856		Roberts, J., George-street.
1868	P 7	Roberts, Alfred, M.R.C.S. *Eng.*, Hon. Mem. Zool. and Bot. Soc. Vienna, Phillip-street.
1876		Roberts, Rev. W. H., B.A., *Dublin*, St. Paul's College, Newtown.
1871		Robertson, Thomas, M.P., Pitt-street North.
1872		Robinson, His Excellency Sir Hercules, K.C.M.G., Governor of New South Wales, Government House.
1873		Rogers, Rev. Edward, Rural Dean, Fort-street.
1856	P 10	†Rolleston, Christopher, Auditor General, Castlereagh-street.
1865		Ross, J. Grafton, 24, Bridge-street.
1876		Rowling, Dr., Mudgee.
1864	P 9	†Russell, Henry C., B.A., *Syd.*, F.R.A.S., F.M.S., Hon. Mem. S. Aust. Inst., Government Astronomer, Sydney Observatory, *Vice-President.*
1875		Sahl, Charles L., German Consul, Consulate of the German Empire, Wynyard Square.
1876		Saliniere, Rev. E. M., Glebe.
1876		Samuel, The Hon. Saul, C.M.G., M.L.C., Gresham-street.
1876		Schuette, Rudolf, M.D., Univ. *Göttingen*, Lic. Soc. Apoth. *Lond.*, 10, College-street.
1856	P 8	†‡Scott, Rev. William, M.A. *Cantab.*, Hon. Mem. Roy. Soc. Vic., Warden of St. Paul's College, *Hon. Treasurer*, St. Paul's College, Newtown.
1876		Scott, A.W., M.A. *Cantab.*, Ferndale, South Head Road.
1876		Sedgwick, Wm. Gillett, M.R.C.S., *Eng.*, Newtown.
1876		Sharp, James Burleigh, J.P., Clifton Wood, Yass.
1876		Sharp, Henry, Green Hills, Adelong.
1875		Sheppard, Rev. G., Elizabeth-street.
1876		Shields, John, M.R.C.S., *Ed.*, Bega.
1873		Simon, Eugene, Consul for France, French Consulate, George-street.
1875		Slade, G.P., Wheatley, North Shore.
1872		Sleep, John S., 139, Pitt-street.
1852	P 7	†Smith, John, The Hon., M.D., LL.D., *Aberdeen*, M.L.C., F.C.S., Hon. Mem. Roy. Soc. Vic., Professor of Physics and Chemistry in the University of Sydney, 193, Macquarie-street.
1875		Smith, Robt., B.A., *Syd.*, Solicitor, Bridge-street.
1874		Smith, John M'Garvie, 404, George-street.
1876		Smith, R. S., Surveyor General's Office.
1876		Southey, H.E., Oaklands, Mittagong.
1870		Spencer, Walter W., Lyons' Terrace.
1876		Stackhouse, Thos., Commander R.N., Australian Club.
1874		Stephen, Edward M., Macleay-street.
1872	P 1	Stephen, George Milner, B.A., F.G.S., Mem. Geol. Soc. of Germany; Cor. Mem. Nat. Hist. Soc., Dresden; F.R.G.S. of Cornwall; Ashfield.
1857		Stephens, William John, M.A. *Oxon.*, 233, Darlinghurst Road.
1876		Stopps, Arthur J., Surveyor General's Office.

Elected.		
1876		Strong, Wm. Edmund, M.D., *Aberdeen*, M.R.C.S., *Eng.*, Liverpool.
1874		Stuart, The Hon. Alexander, M.P., Colonial Treasurer, Clunes, Cambridge-street, South Kingston, Petersham.
1876		Stuart, Clarendon, Upper William Street South.
1876		Suttor, Wm. Henry, J.P., Cangoura, Bathurst.
1874		Taylor, Chas., M.D. *Syd.*, M.R.C.S., *Eng.*, Parramatta.
1876		Tayler, William George, F.R.C.S., *Lond.*, 219, Pitt-street.
1862	P 4	Tebbutt, John, junr., F.R.A.S., Private Observatory, Windsor.
1876		Tennant, E. G., M.R.C.S.E., Orange.
1870	P 1	Thompson, H. A., O'Connell-street.
1875		Thompson, Joseph, Potts' Point.
1876		Thomas, H., Arding, Narellan.
1876		Thomas, Wm. Smith, M.R.C.S., *Eng.*, Wollongong.
1876		Tibbits, Walter Hugh, Dubbo.
1876		Toohey, J. T., Melrose Cottage, Cleveland-street.
1873		Trebeck, Prosper N., George-street.
1876		Trouton, F. H., A.S.N. Company's Offices, Sydney.
1868		Tucker, William, Clifton, North Shore.
1875		Tulloh, W. H., Margaret-street.
1875		Turner, G., Argyle Terrace, Redfern.
1874		Vessey, Leonard A., Survey Office.
1876		Voss, Houlton H., Union Club.
1867		Walker, Philip B., Telegraph Office, George-street.
1870		Wallis, William, Moncur Lodge, Potts' Point.
1867		Ward, R. D., M.R.C.S. *Eng.*, North Shore.
1876		Waterhouse, J. M.A. *Syd.*, Newington College, Parramatta.
1876		Watkins, John Leo, B.A. *Cantab.*, M.A. *Syd.*, Randwick.
1876		Watson, C. Russell, M.R.C.S., *Eng.*, Camden Terrace, Newtown.
1859		Watt, Charles, New Pitt-street.
1874		Watt, John B., The Hon., M.L.C., 104, Macleay-street.
1876		Waugh, Isaac, M.B., M.C., *T.C.D.*, Parramatta.
1876		Webster, A. S., Union Club.
1867		Weigall, Albert Bythesea, B.A. *Oxon.*, M.A. *Syd.*, Head Master of the Sydney Grammar School, College-street.
1874		White, Rev. James S., M.A., LL.D., *Syd.*, Gowrie, Singleton.
1875		White, Hon. James, M.L.C., Cranbrook, Double Bay.
1876		Wilson, F. H., Newtown.
1876		Windeyer, Hon. W. C., M.A., M.L.A., *Syd.*, King-street.
1876		Wise, George Foster, Immigration Office, Hyde Park.
1874		Wilkinson, C. S., Government Geologist, Department of Mines.
1876		Wilkinson, Henry Toller, Department of Mines.
1862		Williams, J. P., New Pitt-street.
1876		Williams, Percy, Treasury.
1873		Wood, Harrie, Under Secretary for Mines, Department of Mines.
1874		Woodgate, E., Parramatta.
1876		Woolrych, F. B. W., 138, Castlereagh-street.
1872		Wright, Horatio, G. A., M.R.C.S., *Eng.*, Wynyard Square.

HONORARY MEMBERS.

Elected, August, 1875.

AGNEW, Dr., Hon. Secretary, Royal Society of Tasmania, Hobart Town.

BARLEE, The Hon. F., Colonial Secretary of Western Australia, Perth.

BERNAYS, Lewis A., F.L.S., Vice-President of the Queensland Acclimatization Society, Brisbane.

ELLERY, Robert F., F.R.S., F.R.A.S., Government Astronomer of Victoria, Melbourne.

GREGORY, Augustus Charles, F.R.G.S., Surveyor General of Queensland, Brisbane.

HAAST, Dr. Julius von, Ph. D., F.R.S., F.G.S., Government Geologist and Director of the Canterbury Museum, New Zealand.

HECTOR, James, C.M.G., M.D., F.R.S., Director of the Colonial Museum and Geological Survey of New Zealand, Wellington.

M'COY, Frederick, F.G.S., Hon. F.C.P.S., C.M.Z.S., Professor of Natural Science in the Melbourne University, Government Palæontologist, and Director of the National Museum, Melbourne.

MÜLLER, Baron Ferdinand von, C.M.G., M.D., Ph. D., F.R.S., F.L.S., Government Botanist, Melbourne.

SCHOMBURGH, Dr., Director of the Botanic Gardens, Adelaide, South Australia.

WATERHOUSE, F. G., F.G.S., C.M.Z.S., Curator of the Museum, Adelaide, South Australia.

WOODS, Rev. Julian E. Tenison, F.G.S., F.R.G.S., Hon. Mem. Roy. Soc., Vic., Hobart Town, Tasmania.

Elected, December 6, 1876.

COCKLE, His Honor Sir James, Chief Justice, M.A., F.R.S., Brisbane, Queensland.

DE KONINCK, Prof., M.D., Liège, Belgium.

OBITUARY, 1876.

Elected.

1876. CAMERON, Ewen, Balmain.

1876. OSBORNE, James, Wollongong.

1874. RAYMOND, L. C., Union Bank.

1876. CAMERON, A. R., M.D., Richmond.

ANNIVERSARY ADDRESS,

Delivered to the Royal Society, 17*th May*, 1876, *by* Rev. W. B. Clarke, *M.A.*, *F.R.S.*, *F.G.S.*, *&c.*, *Vice-President.*

ERRATA SLIP.

For the correction of errors, this slip should be filled up and returned to the Hon. Secretaries.

Corrected Address.

Name ....

Titles, &c. ....

Address ....

....

Date ....

To-night I have not been enabled to exercise similar caution, but I am equally contented to have personal experience of the continuation of the blessings now being showered upon us.

ANNIVERSARY ADDRESS,

Delivered to the Royal Society, 17th May, 1876, by REV. W. B. CLARKE, *M.A., F.R.S., F.G.S., &c., Vice-President.*

GENTLEMEN,

On the last Anniversary I ventured to draw somewhat largely on your patience by a discussion of two important topics which required a considerable amount of research and made it necessary for me to detain you somewhat longer than usual. To-night I propose to confine myself to the Society itself, and to what may be suggested by the events of the period that has elapsed since I last addressed you.

It is my first duty to mention the Conversazione which was held on the 3rd instant, and was, I understand, a great success. The multiplicity of interesting objects exhibited, and the explanations afforded by the Astronomer and others, gratified a company of three hundred persons, many of whom were the guests of the Society. It was unfortunate that several ladies who had graced the room with their presence suffered from the heavy rain that fell as they returned from the assembly, but after the alarming dryness that had so long threatened and at last had begun to create fears of a continuous drought, they could scarcely complain of what was an undoubted blessing to thousands in the land. I regret that I was not well enough to attend, but at the same time I confess I was warned early in the day by the appearance of the sky, and recrossed the harbour before the hour of meeting.

To-night I have not been enabled to exercise similar caution, but I am equally contented to have personal experience of the continuation of the blessings now being showered upon us.

You have heard from the Treasurer what is our pecuniary condition. Considering the expenses which were incurred for furniture and other unavoidable demands upon us in the form of rent and other necessary obligations, it would seem that the Society's finances are in a satisfactory state; as the bank balance is now somewhat in advance of what it was in May, 1875, whilst the assets exceed the liabilities. But in consideration of future contingencies, of which I will speak presently, economy will have to be used if we are to continue as a self-supporting body.

It is a great mishap that so many former members, some of whom were included in our last year's registration, should have induced the Council to put in force a regulation of the Society which, after notice given at the last Anniversary and not responded to, required the removal of their names from the list.

I express my regret at such necessity; but under our present constitution, not only was the measure justifiable, but it must be apparent to each of us that to join any Society which must be self-supporting, on a pledge implied by the rules of election, and to obtain membership by the implied condition of a small annual contribution, and then to ignore not only the obligation itself but continued reminders of it, is suicidal to the respect due to those who regard a "debt of honor" as imperative as any ordinary obligation in life. And it is also plain, that if we all acted in this way the Society itself would collapse by an act of general bankruptcy.

I am glad, however, to find that notwithstanding this secession and additional losses by death, our numbers are still on the increase, and the roll of members now contains 170 names. Forty new members have been elected since the last Anniversary, and there are some fresh ones elected this evening, and others coming forward.

Having got over this difficulty, and having, as our statistics show, met the demands consequent on the advantages derivable from our better arrangements in respect of house accommodation and

of charges for library and furniture, we have good reason for the conviction that the existence of the Society is strengthened and its further progress assured.

But, gentlemen, we must not let these considerations suffice.

A question might arise—"*cui bono?*" Why are we associated at all? What are our objects? What are our designs? It can, however, hardly be expected that I should again give answer to such inquiries. If we are not of use to each other, nor to the community at large, it would save a great deal of trouble to some of us if we came to a decision to dissolve and retire from these gatherings altogether.

I do not so miscalculate your wishes and views as to agree in such a determination. As I have frequently said before, so I now repeat, that our objects are praiseworthy, and that our endeavours to maintain and occupy a respectable position in the social and intellectual life of the Colony in which we dwell, are deserving of support not only within, but beyond the horizon to which we stretch our expectations. For myself, and may I not add for all of you, I would venture to express a renewed hope, humble as is our present position in the great assemblage of men who are devoting their best energies to the advancement of learning and what is technically called science, that hereafter our Society may expand and increase till it shall be acknowledged to have attained a right, on the score of its usefulness, to the suffrages and liberal support of future generations. To those who go with me in such an aspiration, the words in which we might best express our thoughts would be, "*Esto perpetua.*"

Yet our duty now is clear—not to rest in expectations of the future, but to be diligent and thoughtful in the necessary duties of the present. The suggestions of others and my own agreement with them, lead me, therefore, now to make a distinct allusion and appeal on what is at this time needful to be considered.

We have already elected, to the satisfaction of those who have been so elected, into the rank of Honorary members, many gen-

tlemen distinguished for their attainments and recognized position in the fields of science in other Colonies, who would not so willingly have joined our Society had they not been assured that, in so doing, they become members of a body that has in itself not only some vitality, but is active and vigorous.

As our foreign associates have conferred some dignity upon us, let us not forget that we are expected to show that we do not forget our obligations to them and to ourselves.

Thinking over what I am satisfied would be wise and profitable, and what may perhaps not be very difficult to obtain, I propose to you to apply for a Charter. It may be true that at present we have very little property; and if that is a fatal objection, the wish for incorporation may at this moment be premature.

But the most renowned of Societies in Great Britain had as small a beginning as our own; and its incorporation has made it an institution in the land to which it is now reckoned a chief honor to belong;* and in a less degree, but measured in proportion to the smallness of the population of this country, elections to our Society would be then considered not so much a mere temporary contribution to our treasury, as a significant token of respect for such as are "wise in their generation," and anxious for its advancement.

Placing before you, gentlemen, this suggestion for your further consideration, I would now appeal to you on a subject which is equally deserving of attention, and which is wholly in your power, whatever becomes of support from without.

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* When this allusion to the Royal Society of London was made, the author of the Address did not know that he had been selected by the Council of that Society for election to a Fellowship, which took place on 1st June, a fortnight after the delivery of the Address. This circumstance would not here be noticed in this place were it not (as afterwards transpired), that one of the grounds of recommendation for election was the following:—

"4. Important part taken in the re-founding of the Royal Society of New South Wales, and in the promotion of scientific knowledge in the Colony."

It may be satisfactory to the members of this Society to have thus shared in the honor conferred on one of their members, and to have such evidence of the interest taken in our proceedings by the leading Society in England.

You cannot but have noticed that the actual work done in our Society has fallen upon a few only of its members.

It has been suggested that there would be more contributors to our Transactions if those whose attention has been turned to any given subject, whether of a scientific, a literary, or any other class, were associated together in Sections or Committees. It is surmised that in such a case men who could now enlighten us on various interesting subjects might in notices, however brief, fill up gaps left in discussions by their fellow-members who sometimes in discursive essays have left unnoticed many apparently trifling, but really important, facts or suggestions.

It is not an easy task (I speak from experience) to discuss any topic with the conviction that nothing more remains to be said. And on those particular subjects which especially pertain to the objects set forth in our Fundamental Rules, many are the observations which have been made by different persons, which by such a sectional arrangement as is suggested would doubtless find a place in the record of our proceedings.

Short notes might often contain materials for long meditation and inquiry, and as the Council of the Society has authority to determine what shall or what shall not be read at our monthly meetings, no great mischief would eventually be done, even if such communications as have been alluded to might, perchance, contain useless or indefensible matter. Such would, undoubtedly, be put out of the way of public recognition.

All this is, however, only suggestive on my part; but I recommend it to the consideration of all who are sincerely and heartily interested in the progress of the Royal Society.

There are, it may be, thousands of facts of apparently little importance at the moment of observation—or they may be observed by men unused to scientific, or, as the term is, philosophical inferences, which nevertheless are deserving of being registered, as either bearing on some past discussion or leading to some future application. This kind of contribution to our work would be happily brought into the common garner by the

device of small Committees, who would take in charge the collection of all matters bearing on any division of the subject for the illustration of which they would be thus specially set apart. The humblest contributor would in this way find his observations not lost, but probably utilized when recorded in what I am glad to find has at last been commenced,—viz., the *Proceedings* of our Society.

A similar consideration in relation to scientific progress has been expressed by thinkers at Home, in much stronger terms than I have ventured to employ. For instance, a writer in the *Geological Magazine* for January, 1876, has set before his readers some powerful arguments as to the way in which particular sciences must be cultivated hereafter. As his remarks bear upon some of those just made by myself, and are applicable to other subjects as well, I will quote one or two. "If," says the author, "the geologist wishes now-a-days to increase our general stock of knowledge, he cannot study in detail rock formations and palæontology, nor can he take up palæontology as a whole; he must devote himself particularly to one or other of the great classes of animals or to plants whose remains are preserved to us in a fossil state."

"The testimony of a man who would undertake to name a collection of igneous rocks, and at the same time undertake the identification of a series of fossil bones, shells, corals, or other organic remains, would be received with a certain amount of caution."

Again, "As an illustration, one would be surprised to hear that Professor Ramsay was about to describe a new species of fossil bird, or that Professor Huxley had elucidated the stratigraphical relations of the Devonian rocks; that Professor Prestwich would report on the affinities of Graptolites, or that Mr. Etheridge had undertaken the microscopical examination of igneous rocks. And yet each one would naturally be acquainted with the general results of study in each department of geology."

Now, although these quotations appertain to the divisions of work in building up of one science—they may be applied with tenfold force to divisions of study and labour in the whole range of topics included in the aims of such a Society as ours,—though it be chiefly directed towards the study of the physical history of Australia. One man sees one thing, another man observes another thing. When these separate parts are brought together, all of them assist towards completion of the whole object. The manufacture of a single pin requires numerous skilled workmen, and so in any science to do the work effectually there are required numerous observers and skilful application of principles. If, therefore, there be any member of this Society who can contribute to any particular branch of study, let him associate himself with others in mutual investigations, and we shall then realize the Sectional or Committee arrangement proposed.

I know there are with us several good Astronomers, some good Botanists, some clever Mathematicians, Chemists, Surveyors, and Engineers, &c., &c. Now, would not more good come from mutual assistance to each other in the work of our body, if, in each department of science, or art, or literature, facts were brought together from different quarters all tending one way, viz., towards the completion of our knowledge ?

There is one other important consideration which ought not to be neglected.

All persons who have entered upon any kind of scientific study know how needful it is to have the fullest information respecting the state of the particular science which they cultivate. And this is well put in the paper from which I have already quoted two passages. "The literature of the science," says the author, "is such a vast subject that before adding to it one must necessarily learn what has been previously done, and whether one is in possession of any facts not made public, or of any explanations or theories not previously suggested. To study the literature of all branches of geological and palæontological research would indeed be a Herculean task. It is true that our standard manuals

and text-books put us in possession of the leading facts and conclusions, but our magazines and journals are ever increasing the number of facts and of observers."

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"And after all, the high-water-mark of thought (as Professor Huxley puts it) consists in dealing with educational, scientific, and philosophical subjects in a broad, general, and interesting way, so that one may get out of the groove in which one's special work lies, and afford time for the consideration of subjects the outcome of special work in all departments of science." [Geological Progress, *Geological Magazine, January*, 1876.]

I would illustrate this by the volume to which I now refer. It is the first of a series, intended to be annual,—a Catalogue with short abstracts of works on Geology, Mineralogy, and Palæontology, published during any given year.* It was undertaken by gentlemen who have long felt the necessity of a record of the kind. This, the first volume, gives a list of publications on the subjects named during the year 1874, and it occupies 378 closely printed pages, together with an index of 19 pages more, each page arranged in three columns, each of which gives forty or fifty distinct articles. Even this, however, is hardly sufficient to embrace everything that was written in 1874, and gives no room for any works preceding that date.

Such then being the case, the members of our Society require the advantages to be found in a good library of scientific and philosophical works; and the Council have been endeavouring to supply it partially by allowing the sum of £30 for the purchase of periodicals. We need, however, more than this small expenditure. If the Government would contribute somewhat liberally for the purpose of starting and supporting a library of such scientific works as our Society requires, it would serve a double purpose; it would enable us to turn its patronage to good account, and would also be a strong argument for the Incorporation before suggested.

* "Geological Record"—edited by William Whitaker, B.A., F.G.S., of the Geological Survey of England.

An application was made nearly two years ago by myself and a member of the present Council to the Minister of Public Instruction respecting a grant for our special purposes, and this application was favourably received; but, in consequence of objections raised by some of our members, the necessary steps were not then taken to bring the matter before the Parliament. The objectors thought it was not right to place this Society on the same footing as a mere School of Arts, which sometimes becomes a circulating library of light literature; but it was altogether forgotten that the Royal Society of Great Britain receives a grant (I believe, yearly) from the Parliament for its general purposes. And I do not doubt that a proper statement of our application would have met with no denial. We may, I think, appeal to-night to such private individuals as may be willing to contribute to our library, works of scientific value in their possession which they could spare, and I have sufficient faith in the kindly disposition of many in this community in relation to the "higher education" as it is called, to believe that our incipient library might, in this way, be gradually increased, though not so efficiently at once as by the Government itself.

Relieved of some of our internal expenses in this way, our own funds might go in another direction in helping to obtain a residence for the Society free of rent, the amount of which could then be employed in necessary wants that would be sure to arise on its establishment and extended undertakings. By the active exertions of our Secretaries a wide correspondence has been opened with kindred Societies in Europe and America, and the greatest desire has been expressed by leading Associations to exchange publications with us.

Messrs. Trübner and Co., of London, have also offered to be our agents in the business of such exchanges, and the President of the Smithsonian Institution in America has not only endorsed the circular on the subject, issued by us last year, but has undertaken to collect publications for our service from the various Societies in the United States and Canada. An abstract of this correspondence has been placed in your hands.

Whilst thus dealing with those affairs of our Society which ought now to have the strongest claims upon its members, I am by no means inclined to overlook the progress of other Associations; such, for instance, as the Linnean Society of Sydney, or that Society in whose room we are now assembled, and which has already been assisted by public money. Any right-thinking person must rejoice in the advancement of mental research, when conducted under the wholesome influence of sound moral principles, not forgetting the Author of all we see and speak of, because the study of Nature as it is termed, will in the end, if properly pursued, lead only to higher aims and an access to truth, or *what is*. But it would seem to me, looking at things in a matter-of-fact way, that a multiplication of Associations in a limited population only tends to the weakness of all; and if the scheme pointed out of sectional Committees were put in force, it would be in the power of any Society, with such a range as ours, to meet all the exigencies of the case. In this respect New Zealand has already led the way, and all her former Provincial Societies are now consolidated in the comprehensive New Zealand Institute. As concerns ourselves the scheme would for the present be confined to this Colony alone. I must add, however, that I look with no jealousy on the success of other Societies, and that the first Address of the President of the new Linnean Society, on the Progress of Natural History in Australia, furnishes a valuable contribution to the literature of science. I do not know if there be any other suggestion of great importance at this time to require attention; but, if such should arise, it may be noticed hereafter.

Obituary.

Let me now refer to the losses which the Society has sustained by death since the last Anniversary.

Although but one of these deceased members was an actual contributor to our Transactions, four deserve commemoration as publicly connected with the advancement of Australia by exploration, or by identification with its literary or scientific progress.

Mr. Edward S. P. Bedford joined this Society in 1864, the year after his arrival in Sydney, and contributed in 1866 to the then Philosophical Society "Remarks on the support of the young of marsupial animals in the pouch," which he illustrated by a diagram and various marsupial bones. To the Transactions of the Royal Society he contributed in 1867 a paper "on the reappearance of scurvy in the merchant service," and in 1868, a communication "on dry earth conservancy."

He had been for several years before an active member of the Royal Society of Tasmania, of which he remained a Corresponding member to the time of his death on 24th February, 1876, at the age of 67.

He had held some important medical offices in Tasmania, and was at one time a member of its Legislative Council. On his departure from that Colony an Address was presented to him from the leading members of his profession, and another from the Judges, President, Speaker, Ministers, Magistrates, and Clergy, bearing witness to his ability and public usefulness, and to the high qualifications of his social character.

On arrival in New South Wales he was received with respect for his previous reputation, and obtained several official appointments which he held at the time of his death. In all my intercourse with him I found him kind, gentlemanly, and intelligent, and a warm supporter of the two Royal Societies, in each of which he had been an administrator. He was Honorary Treasurer and member of Council of this Society from 1867 to 1874. To his praise be it said, he established in Tasmania a hospital of his own of which he took the management, his medical brethren on his departure testifying "their entire confidence and esteem, which he had gained by the unvarying exercise of unswerving integrity and the strictest professional honor and courtesy in all the numberless instances in which they had been brought together."

He was son of the senior Chaplain in Tasmania, the Rev. Dr. Bedford, and brother-in-law of our late highly respected Chief

Justice, Sir A. Stephen, C.B., K.C.M.G., now Deputy-Governor of New South Wales.

MR. HOWARD REED arrived in this Colony about 1867, and soon after became a member of this Society. He was the youngest son of Dr. Andrew Reed, and brother of Sir Charles Reed, who for some time had a seat in the Imperial Parliament, and is still, I believe, Chairman of the London Board of Education.

The father of these gentlemen was a man of great benevolence, and had been mainly instrumental in the erection of no less than six hospitals and asylums in England.

The subject of our notice chose Agriculture as his pursuit, and to his exertions the Agricultural Society of New South Wales is mainly indebted for its existence. He was also connected with the Press in England and this Colony, and his contributions to various journals have elicited the respectful attention of numerous readers. After an illness of some months' duration Mr. Reed died on 23rd October, at the age of forty-eight. He did not contribute any written paper to our Transactions, but he took part in our oral discussions.

A third loss by death occurred in the death of Dr. JOHN PIERCE, of Maitland, whose membership dates from 1873; but, as I have been unable to learn any particulars of his career, I content myself with recording his decease.

Mr. W. HOVELL, of Goulburn, commonly called Captain Hovell, as in early life he had been a commander in the mercantile marine, joined the Society in 1868. He was associated with Mr. Hamilton Hume in the exploration of the country to the south and south-west. He was with Mr. Hume when he discovered the country beyond the Murrumbidgee River, in 1824. An expedition having been projected by Sir Thomas Brisbane, the then Governor, to traverse the land from Wilson's Promontory to Sydney, Hume and Hovell shared the cost of the expedition which they undertook; but their journey was made from Lake George to Western Port, and the exit was actually about Geelong. Mr. Hume's name was given to the upper part of the

Murray, which they jointly discovered, and in after years this gave rise to a controversy between the explorers, which, as in many other similar cases, called forth much needless acrimony.

A very fair account of the work done by these "first Overlanders," as they are named by one of your recently elected Honorary Members, the Rev. Julian E. Tenison Woods, in his "History of the Discovery and Exploration of Australia," gives to Mr. Hume the distinction of leader; and he was so in more senses than one, having first discovered the country round Berrima, at the age of seventeen, in the year 1814, and afterwards Lake Bathurst in 1817, and for these he received a grant of 300 acres of land.

The Murrumbidgee had been discovered by Currie and Ovens in 1823, before Hume and Hovell started on the overland route to Port Phillip, during which the latter two had discovered the Southern Alps and various rivers flowing from them.

Mr. Woods says justly:—"Their expedition was, without doubt, one of the most important made in Australia, as far as the value of the country discovered is concerned. The New South Wales Government fully appreciated this, and Messrs. Hume and Hovell were both rewarded by a grant of land of 1,200 acres each." Mr. Hovell afterwards explored the Western Port district, which they were at first commissioned to visit, and which Hovell fancied he had reached when the party arrived at Port Phillip.

It is not worth our while now to discuss the controversy respecting the share each may have had in first making out any particular part of the country traversed. As their initials were cut on two neighbouring trees not far from what is now Geelong, and, I believe, were not long since recognizable, no doubt can exist that both were sharers in the labour and toil of the whole exploration, Mr. Hovell therefore should have his share of credit. Though the name of "Hume River" was afterwards supplanted by Captain Sturt's name "The Murray," and Hovell's name given by himself to the "Goulburn" still retains the name assigned to it by Hume, yet Mr. Hovell deserves remembrance by ourselves

as one of the pioneers in the great undertaking of opening up a vast territory, a great portion of which is now in the occupation and government of the sister Colony, Victoria, but was for a long time part of New South Wales. Mr. Hovell was born, I believe, about 1785, and Mr. Hume on 18th June, 1797. The former, therefore, was fully 90 years of age, and may be considered in our records, in relation to the late Alexander Berry, as the twin nonagenarian of our Society. Mr. Hume died in April, 1873.

Commodore Goodenough, R.N.

It is impossible to name the late Commodore Goodenough, who joined us shortly after his arrival, without calling to mind the deep feelings which stirred the whole community when the first news of his death accompanied the arrival of his body for interment.

In the short intercourse with him with which some of us were honored, we could not but learn to appreciate the sterling excellencies of his disposition and the disinterestedness of his character, amply illustrated as these have been by the facts related of his death in the discharge of his voluntary efforts as a christian man to conciliate the savages by whom he was treacherously slain.

His merits have been honorably acknowledged by the Sovereign and Country whom he served with success during a period of two-and-thirty years. In May, 1844, he entered the Navy, became captain in May, 1863, and after a distinguished career was decorated with the insignia of C.B. and C.M.G.

It may seem a work of supererogation in me to venture now on any further tribute to his memory; but as he rendered good service to this Colony, especially in relation to the annexation of Fiji, in which he took a prominent part, we seem to have lost one of our best public friends, and such he was in more senses than one.

He now rests in peace between two youthful seamen, each eighteen years of age, belonging to H.M.S. "Pearl" under his com-

mand, who lost their lives in the same calamity, and but a short space from the tomb of a friend of my own and a connexion of the Commodore, Captain Owen Stanley, R.N., who died in command of H.M.S. "Rattlesnake" in 1850, and over whose remains it was my sad duty to officiate. To him also was accorded, as to Commodore Goodenough, a public funeral.

It was a satisfaction to have enrolled in our list of members, though for so short a time, one who was so distinguished as the latter, and who expressed so deep an interest in the welfare of our Society which he had promised to assist by future communications.

As to his professional character it would not become me to venture an opinion. I can do far better by quoting the testimony of a brother officer of equal rank with himself, to whom he had long been known: "As I write these lines," says Captain Moresby (who was here not long since in command of H.M.S. "Basilisk"), "a telegram has arrived announcing the death of Commodore Goodenough, C.B., C.M.G., commanding on the Australian station, by the poisoned arrows of the natives of Santa Cruz Island. I desire to pay my humble tribute of sorrow and admiration to the memory of this man, with whom I am happy in having held a private friendship for twenty-five years. I do not speak of the loss his friends sustain in him; of the generous nature, full of large kindness and the power of sympathy; of the sound, helpful judgment that was ever ready for any call that could be made on it, for this is sacred ground;—I speak of him only as a public man, and would say that, though I have warmly appreciated him all through, as he rose in our service, I never knew his full professional worth till I had the honor of serving under him in Australia.

"Then, his grasp of mind in dealing with a subject, his self-reliance and readiness to take responsibility, his happy way of taking his captains into his confidence, whilst always holding the reins himself, of giving praise liberally where praise was due, and cordial support or advice where either was needed, produced an impression on my mind of greatness in store for him in the future which can now never, alas! be made good. His fine scientific

and sailorlike qualities, his promptitude, his iron nerve, combine with his other gifts to make his loss a national one, and as such it will be doubtless be regarded, and this will be some consolation to his friends; but their best will lie in the knowledge that his pure and devout spirit was ever ready to enter the presence of its Maker."

The death of the Commodore was felt as a serious loss at Home and by the Admiralty and the Naval Service at large, as evidenced by a prospectus of a "Goodenough Memorial Fund," a copy of which lately received from England I lay upon the table, inviting any of our members to subscribe to it who may feel that, in so doing, they are acknowledging the services of one who deserved a memorial such as Plato (*Menexenus*) tells us heathen Greece accorded to the survivors of all who fell in the service of their country; for, as was held by Pericles (Thucyd. II. 34), "they who by their acts had shown true courage should by corresponding acts of gratitude be honored."

There are some interesting circumstances relating to the scene of the late Commodore's martyrdom which may, I trust, not be considered impertinent to mention at this meeting.

Scarcely four years had elapsed since Bishop Patteson, who was well known to the natives of Santa Cruz, and had often been among them, was, with two of his companions, also stricken and slain. "Suddenly, without any previous warning (it is related by one of his biographers) a man rose, and saying, "Have you got anything like this?" let fly an arrow, which was quickly followed by a volley from his seven companions. Mr. Atkin was shot in the left shoulder, whilst of the three Melanesians one of them was wounded slightly, and the other was pierced by no fewer than six arrows. Every arrow had thus taken effect."

Seven years before this, two youths belonging to the Melanesian Mission were slain also at Nupuku, close to Santa Cruz;* and, if I mistake not, since then other victims perished in the

* Sketches of the life of Bishop Patteson in Melanesia, p. 185.

same way. History records also other calamities of like kind in the same group of islands.

Captain Carteret, in August, 1767, more than a century before the visit of the "Pearl," experienced the very same hostility and treachery which distinguished the fate of Bishop Patteson and Commodore Goodenough. In the 4th chapter of his Voyage, he gives an "Account of the Discovery of Queen Charlotte Islands, with a description of them, their Inhabitants, and of what happened at Egmont Island." The latter "certainly is," he says, "the same to which the Spaniards have given the name of Santa Cruz, as appears by the accounts which the writers have given of it."

If we compare the statements published respecting the deaths of the Bishop and the Commodore with Carteret's statements, we shall find the same circumstances in each,—too great confidence in the natives, and the greatest jealousy and treacherous conduct on the part of the latter. Bishop Patteson laid great stress, in his "Memorial on the South Sea Labour Traffic," on the cause of evil and death in the Pacific, and quotes the testimony of the commander of a whaling ship to the same effect.

The latter says what the Bishop confirms:—"The natives of these islands would come off in former years, bringing such articles of trade as their islands afford, for which we paid them with hatchets, tobacco, fish-hooks, &c. They trusted us and we trusted them. At times our decks were crowded. This, when slavery commenced, was all to the slaver's advantage, for the natives were easily enticed below, the hatches put on, and the vessel was off. Now no natives come on board the whale-ship, and we in our turn dare not land. Again, we used to carry people from one island to another when they wished it, and they would give us hogs and other articles. This also has been taken advantage of, and the natives carried into slavery instead of home. Should we be wrecked our lives must go for those that have been stolen, and the natives will be condemned and called blood-thirsty, &c., and yet what have the natives done? Not certainly right, but no more than civilized people have done in many cases. I hear they use your name" (*i.e.*, the Bishop's) "to decoy natives from their

islands; and I also hear, from good authority, that they inquire very particularly of the whereabouts of the Southern Cross." —*Memorial*, p. 201.

Doubtless, this testimony to the consequences of a recent nefarious traffic is not the whole explanation of the conduct of natives of certain islands, Santa Cruz in particular. For, more than a century ago, Captain Carteret found the same characteristics in the inhabitants of Santa Cruz as were exhibited towards the Bishop and the Commodore when there were no slave-dealers and kidnappers on whom to lay the blame.

But few persons, comparatively, have ever read the narrative of Captain Carteret. At the risk of occupying too much of our time, I cannot resist, with your permission, the reading of a portion of his statement, which has been copied for me at my request.

Extract from Captain Carteret's account of the discovery of Queen Charlotte's Islands, with a description of them, their inhabitants, and of what happened at Egmont Island—[August 1767.]

"The next morning, therefore, as soon as it was light, I dispatched the master, with fifteen men, in the cutter, well armed and provided, to examine the coast to the westward, our present situation being on the lee of the island, for a place where we might more conveniently be supplied with wood and water, and, at the same time, procure some refreshments for the sick and lay the ship by the stern to examine and stop the leak. I gave him some beads, ribbons, and other trifles, which by chance I happened to have on board, to conciliate the good-will of the natives, if he should happen to meet with any of them; but at the same time enjoined him to run no risk, and gave him particular orders immediately to return to the ship if any number of canoes should approach him which might bring on hostilities; and if he should meet the Indians in small parties, either at sea or upon shore, to treat them with all possible kindness, so as to establish a friendly intercourse with them; charging him on no account to leave the boat himself nor to suffer more than two men to go on shore at

a time, while the rest stood ready for their defence; recommending to him, in the strongest terms, an application to his duty, without regarding any other object, as the finding a proper place for the ship was of the utmost importance to us all; and conjuring him to return as soon as this service should be performed, with all possible speed.

"Soon after I had dispatched the cutter on this expedition, I sent the long boat with ten men on board well armed to the shore, who before 8 o'clock brought off a tun of water. About 9 I sent her off again, but soon after seeing some of the natives advancing along the shore towards the place where the men landed, I made the signal for them to return, not knowing to what number they would be exposed, and having no boat to send off with assistance if they should be attacked.

"Our men had not long returned on board, when we saw three of the natives sit down under the trees abreast of the ship. As they continued there gazing at us till the afternoon, as soon as the cutter came in sight, not caring that both the boats should be absent at the same time, I sent my lieutenant in the longboat with a few beads, ribbons, and trinkets, to endeavour to establish some kind of intercourse with them, and by their means with the rest of the inhabitants; these men, however, before the boat could reach the shore, quitted their station, and proceeded along the beach. As the trees would soon prevent their being seen by our people, who were making towards the land, we kept our eyes fixed upon them from the ship, and very soon perceived that they were met by three others. After some conversation, the first three went on, and those who met them proceeded towards the boat with a hasty pace. Upon this I made the signal to the lieutenant to be upon his guard, and as soon as he saw the Indians, observing that they were more than three, he backed the boat in to the shore, and making signs of friendship, held up to them the beads and ribbons which I had given him as presents, our people at the same time carefully concealing their arms. The Indians, however, taking no notice of the beads and ribbons,

resolutely advanced within bow-shot, and then suddenly discharged their arrows, which happily went over the boat without doing any mischief; they did not prepare for a second discharge but instantly ran away into the woods, and our people discharged some muskets after them, but none of them were wounded by the shot. Soon after this happened the cutter came under the ship's side, and the first person that I particularly noticed was the master, with three arrows sticking in his body. No other evidence was necessary to convict him of having acted contrary to my orders, which appeared more fully from his own account of the matter, which it is reasonable to suppose was as favourable to himself as he could make it. He said that, having seen some Indian houses with only five or six of the inhabitants, at a place about fourteen or fifteen miles to the westward of the ship's station, where he had sounded some bays, he came to a grappling, and veered the boat to the beach, where he landed with four men, armed with muskets and pistols; that the Indians at first were afraid of him, and retired, but that soon after they came down to him, and he gave them some beads and other trifles with which they seemed to be much pleased; that he then made signs to them for some cocoa-nuts, which they brought him, and with great appearance of friendship and hospitality gave him a broiled fish and some boiled yams; that he then proceeded with his party to the houses, which, he said, were not more than fifteen or twenty yards from the water-side, and soon after saw a great number of canoes coming round the western point of the bay, and many Indians among the trees; that, being alarmed at these appearances, he hastily left the house where they had been received, and with the men, made the best of his way towards the boat; but that, before he could get on board, the Indians attacked, as well those that were with him as those that were in the boat, both from the canoes and the shore. Their number, he said, was between 300 and 400; their weapons were bows and arrows—the bows were 6 feet 5 inches long, and the arrows 4 feet, which they discharged in platoons as regularly as the best disciplined troops in Europe. That it being necessary to defend himself and his people when

they were thus attacked, they fired among the Indians to favour their getting into their boat, and did great execution, killing many and wounding more. That they were not however discouraged, but continued to press forward, still discharging their arrows by platoons in almost one continued flight; that the grappling being foul occasioned a delay in hauling off the boat, during which time he and half of the boat's crew were desperately wounded; that at last they cut the rope, and ran under their foresail, still keeping up their fire with blunderbusses, each loaded with 8 or 10 pistol balls, which the Indians returned with their arrows, those on shore wading after them breast-high into the sea. When they had got clear of these the canoes pursued them with great fortitude and vigour till one of them was sunk and the numbers on board the rest greatly reduced by the fire, and then they returned to the shore. Such was the story of the master, who, with three of my best seamen, died some time afterwards of the wounds they had received; but, culpable as he appears to have been by his own account, he appears to have been still more so by the testimony of those who survived him. They said that the Indians behaved with the greatest confidence and friendship till he gave them just cause of offence by ordering the people that were with him, who had been regaled in one of their houses, to cut down a cocoa-nut tree, and insisting upon the execution of his order notwithstanding the displeasure which the Indians strongly expressed upon the occasion; as soon as the tree fell all of them except one, who seemed to be a person of authority, went away, and in a short time a great number of them were observed to draw together in a body among the trees by a midshipman who was one of the party that were on shore, and who immediately acquainted the master with what he had seen, and told him that from the behaviour of the people he imagined an attack was intended; that the master made light of the intelligence, and, instead of repairing immediately to the boat, as he was urged to do, fired one of his pistols at a mark; that the Indian, who had till that time continued with them, then left them abruptly and joined the body in the wood; that

the master, even after this, by an infatuation that is altogether unaccountable, continued to trifle away his time on shore, and did not attempt to recover the boat till the attack was begun.

* * * * * * *

"The next morning, the weather being fine, we veered the ship close in shore with a spring upon our cable, so that we brought our broadside to bear upon the watering-place for the protection of the boats that were to be employed there. As there was reason to suppose that the natives, whom we had seen among the trees the night before, were not now far distant, I fired a couple of shots into the wood before I sent the waterers ashore; I also sent the lieutenant in the cutter well manned and armed with the boat that carried them, and ordered him and his people to keep on board and be close to the beach to cover the watering boat while she was loading, and to keep discharging muskets into the wood on each side of the party that were filling the water. These orders were well executed. The beach was steep so that the boats could lie close to the people that were at work; and the lieutenant from the cutter fired three or four volleys of small arms into the woods before any of the men went on shore, and none of the natives appearing, the waterers landed and went to work. But notwithstanding all these precautions, before they had been on shore a quarter of an hour, a flight of arrows was discharged among them, one of which dangerously wounded a man that was filling water in the breast, and another stuck into a bareca on which Mr. Pitcairn was sitting. The people on board the cutter immediately fired several volleys of small arms into that part of the wood from which the arrows came, and I recalled the boats that I might effectually drive the Indians from their ambuscades with grape-shot from the ship's guns. When the boats and people were on board we began to fire, and soon after saw about two hundred men rush out of the woods and run along the beach with the utmost precipitation. We judged the coast to be now effectually cleared, but in a little time we perceived that a great number had got together on the westernmost point of the bay, where they probably thought themselves beyond our

reach. To convince them, therefore of the contrary, I ordered a gun to be fired at them with round shot; the ball just grazing the water rose again and fell into the middle of them, upon which they dispersed with great hurry and confusion, and we saw no more of them. After this we watered without any further molestation, but all the while our boats were on shore we had the precaution to keep firing the ship's guns into the wood on both sides of them, and the cutter—which lay close to the beach, as she did before—kept up a constant fire of small arms in platoons at the same time. As we saw none of the natives during all this firing, we should have thought that none of them had ventured back into the wood, if our people had not reported that they heard groans from several parts of it, like those of dying men.

"The master was dying of the wounds he received in his quarrel with the Indians; the lieutenant also was very ill; the gunner and thirty of my men incapable of duty, among whom were seven of the most vigorous and healthy that had been wounded with the master, and three of them mortally, and there was no hope of obtaining such refreshments as we most needed in this place. These were discouraging circumstances, and not only put an end to my hopes of prosecuting the voyage farther to the southward but greatly dispirited the people. Except myself, the master, and the lieutenant, there was nobody on board capable of navigating the ship home; the master was known to be a dying man, and the recovery of myself and the lieutenant was very doubtful. Not being in a condition to risk the loss of any more of the few men who were capable of doing duty, I weighed anchor at daybreak on Monday the 17th, and stood along the shore for that part of the island to which I had sent the cutter. To the island I had given the name of Egmont Island, in honor of the Earl; it certainly is the same to which the Spaniards have given the name of Santa Cruz, as appears by the accounts which the writers have given of it, and I called the place in which we had lain Swallow Bay. When we had proceeded about three leagues from the harbour we opened the bay

where the cutter had been attacked by the Indians, to which, for that reason, we gave the name of Bloody Bay. In this bay is a small rivulet of fresh water, and here we saw many houses regularly built; close to the waterside stood one much longer than any of the rest, which seemed to be a kind of common hall or council-house, and was neatly built and thatched. This was the building in which our people had been received who were on shore here with the master, and they told me both the sides and floor were lined with a kind of fine matting, and a great number of arrows, made up into bundles, were hung up in it ready for use. They told me also that at this place there were many gardens, or plantations, which were enclosed by a fence of stone, and planted with cocoa-nut trees, bananas, plantains, yams, and other vegetables; the cocoa-nut trees we saw from the ship, in great numbers, among the houses of the village. About three miles to the westward of this town we saw another of considerable extent, in the front of which, next to the waterside, there was a breast-work of stone, about 4 feet 6 inches high, not in a straight line, but in angles, like a fortification; and there is great reason to suppose, from the weapons of these people, and their military courage, which must in great measure be the effect of habit, that they have frequent wars among themselves. As we proceeded westward from this place we found, at the distance of two or three miles, a small bight, forming a kind of bay, in which a river empties itself. Upon taking a view of this river from the mast-head, it appeared to run very far into the country, and at the entrance, at least, to be navigable for small vessels. This river we called Granville's River, and to the westward of it is a point, to which we gave the name of Ferrer's Point. From this point the land forms a large bay, and near it is a town of great extent, which seemed to swarm like a beehive: an incredible multitude came out of it as the ship passed by, holding something in their hands which looked like a wisp of green grass, with which they seemed to stroke each other, at the same time dancing or running in a ring. About seven miles to the westward of Point Ferrers is another, that was called Carteret Point, from which a reef of

rocks that appears above water runs out to a distance of about a cable's length. Upon this point we saw a large canoe, with an awning or shade built over it; and a little to the westward, another large town, fronted, and probably surrounded, with a breastwork of stone like the last; here also the people thronged to the beach as the ship was passing, and performed the same kind of circular dance. After a little time they launched several canoes and made towards us, upon which we lay to, that they might have time to come up, and we conceived great hopes that we should prevail upon them to come on board, but when they came near enough to have a more distinct view of us they lay upon their paddles and gazed at us, but seemed to have no design of advancing further, and therefore we made sail and left them behind us. Having hauled round this cape, we found the land trend to the southward, and we continued to stand along the shore till we opened the western passage into the lagoon between Trevanion's Island and the main land. In this place, both the main and the island appeared to be one continued town, and the inhabitants were innumerable. We sent a boat to examine this entrance or passage, and found the bottom to be coral and rock, with very irregular soundings over it. As soon as the natives saw the boat leave the ship they sent off several armed canoes to attack her; the first that came within bow-shot discharged their arrows at the people on board, who, being ready, fired a volley, by which one of the Indians was killed and another wounded; at the same time we fired a great gun from the ship, loaded with grape shot, among them, upon which they all pulled back to the shore with great precipitation, except the canoe which began the attack, and that being secured by the boat's crew, with the wounded man in her, was brought to the ship. I immediately ordered the Indian to be taken on board, and the surgeon to examine his wounds; it appeared that one shot had gone through his head, and that his arm was broken by another. The surgeon was of opinion that the wound in his head was mortal, I therefore ordered him to be put again into his canoe, and, notwithstanding his condition, he paddled away towards the shore. He was a young man, with a

woolly head like that of the negroes, and a small beard, but he was well-featured, and not so black as the natives of Guinea; he was of the common stature, and, like all the rest of the people whom we had seen upon the island, quite naked. His canoe was very small, and of rude workmanship—being nothing more than part of the trunk of a tree made hollow; it had, however, an outrigger, but none of them had sails.

"The inhabitants of Egmont Island, whose persons have been described already, are extremely nimble, vigorous, and active, and seem to be almost as well qualified to live in the water as upon the land, for they were in and out of their canoes almost every minute. The canoes that came out against us from the west end of the island were all like that which our people brought on board, and might probably, upon occasion, carry about a dozen men, though three or four managed them with amazing dexterity. We saw, however, others of a larger size upon the beach, with awnings or shades over them.

"We got two of their bows, and a bundle of their arrows, from the canoe that was taken with the wounded man; and with these weapons they do execution at an incredible distance. One of them went through the boat's washboard, and dangerously wounded a midshipman in the thigh. Their arrows were pointed with flint, and we saw among them no appearance of any metal."

This, then, is what occurred in 1767. Nor is this all. In 1568, two centuries before (within a year), Mendāna, who about that time discovered Santa Cruz, and all subsequent navigators, whether French or English, found the inhabitants of the great island groups and archipelagoes of that part of the Pacific; ferocious, treacherous, and bloodthirsty; so that conjectures as to the immediate cause of any given catastrophe may be attributed in part to the sudden excitement of the natives or to some imprudence on the part of visitors, as well as to the *utu*, or retaliation on past offenders. In Carteret's account this is distinctly stated; and it is impossible to say in what way the Bishop and the Commodore might have infracted some rule unknown to them. That

the people of Santa Cruz have understanding of the art of defence as well as of attack is shown also by Carteret, who describes their breast-works, and the mode of delivery of their arrow shots in true military style. Captain Moresby, R.N., who visited Santa Cruz in H.M.S. "Basilisk," before the visit of the "Pearl" and after the death of the Bishop, incidently confirms much that was noticed by Carteret respecting these breast-works and the weapons of offence. He says:—"The village" (in Byron's Bay, mentioned by Carteret) "is fortified by low coral walls, breast-high, the openings in which are overlapped by other walls, calculated to throw an attacking party into some confusion."

One thing has puzzled many persons in reference to the treatment of Bishop Patteson after his death. Instead of disposing of the body as cannibals might have done, they wrapped it in native matting, tied at the neck and ankles, thrust a palm frond into the breast, with five knots tied in it—and then placed it in a canoe which was floated away. [See "Sketches, &c.," p. 186.] Mr. Atkin who was wounded at the same time with the Bishop and afterwards died, is recorded to have heard one of the natives say, the Bishop was *tapu*. If this word means the same as *tabu* in Tonga, then it would appear they knew who in some degree the Bishop was, and though they slew him respected his character. They even "put a small kit of yams into the boat upon which they fired." (p. 192.)

It is certain that the visit of the "Basilisk" was of a peaceful character, for Captain Moresby says:—"The friendliness of these natives to us was remarkable, and I have deeply regretted to learn that some difficulty has since arisen between them and H.M. schooner, 'Sandfly,' during her late visit to this place, resulting in the loss of numerous native lives." "An event of this kind," he adds, "is to be regretted, not so much for the present effect, as for the misunderstanding, the want of confidence, and the revengeful feeling it produces in the future."

As Captain Moresby thus alludes to H.M.S. "Sandfly," I have been induced to look up the accounts respecting her adventure, and the following particulars have been met with:—

"The 'Sandfly,' on 14th September, 1874, was at Tapoua, or Edgcombe Island of Carteret, which was surveyed by Captain Moresby, and in which he discovered a very fine harbour, and named it after the 'Basilisk.' The natives appeared friendly but were not armed. On the 17th about thirty canoes came off, well provided with bows and poisoned arrows. The people in them were friendly till dinner-time, when the deck of the 'Sandfly' was nearly cleared; the savages then commenced firing with the arrows in some of the canoes ahead of the ship, which was stopped by a discharge of rifles. The commander of the 'Sandfly' then left the ship to give chase in his gig, and was again fired at with arrows, and after a few rounds from the rifles to clear the bush, the gig went in to the shore, and towed out nine canoes: boats were manned and two villages were burned, and all the canoes destroyed. On the 19th, a man who could speak English, and was a survivor of a vessel that had had an affray at Vanikoro, where the captain was attacked and wounded as well as himself, came off to the 'Sandfly' stating that their boat had drifted on shore owing to the tide at Tapoua, where the captain died and was buried.

"On 20th September, the 'Sandfly' anchored at Santa Cruz. The natives here came off in great numbers, well armed with bows and poisoned arrows, and made an attack on the vessel. This was repulsed, and two villages and several canoes were destroyed by the ship."

This account was first stated in the Sydney *Herald* of 11th December, 1874, but in that journal of 31st October, 1874, there is a memorandum of the reported massacre of the crew of the "Lapwing," of Auckland, which had been attacked at the island of Tafosia, one of the Santa Cruz group, stating that the whole of the crew, save one Tanna man, had been killed, and that the vessel had been destroyed by fire. It seems the "Lapwing" (according to the captain of the "Bruce") ran short of provisions, and the mate and boat's crew proceeded to the shore to obtain some, when the natives attacked the boat,

killed the men in her, seized the vessel and murdered the master and rest of the crew, the latter being Kanakas. This looks certainly like another version of the statement made by the native man at Tapoua just related, especially as the same memorandum mentions that H.M.S. "Sandfly" had been attacked, and a smart engagement had taken place, by which the natives had suffered loss.

Two things seem to point out that, if these accounts relate to the same vessel, she bore two names; for in the "Sandfly's" report the vessel that the Vanikoro man belonged to was the "Tortue," which sailed under French colours, and the "Lapwing" is stated to have been reported from Noumea, in New Caledonia, to Messrs. Montefiore, of Sydney. Whatever happened, it is quite certain that the Santa Cruz people had committed an aggression on an English ship of war, and had been punished severely between the visit of the "Basilisk" in August, 1872, and that of the "Pearl" in August, 1875.

The death of Commodore Goodenough was probably a revenge on the "Sandfly"; the attack on the latter, and the death of the Bishop, perhaps the result of feelings excited by the labour traffic; but the reception of Captain Morseby was friendly, whilst the fact is that "kill-kill" vessels, as certain labour crafts are called by the natives, were objects of aversion, and that if we are to trust an eye-witness (see Brooke's Journal, "Mission Life, 1872, p. 7"), very properly so. Mr. Brooke says, "natives in the island of Florida were captured merely for the sake of their skulls, with which payment was made to the chiefs of neighbouring islands; and canoes on coming alongside a vessel were upset, and their occupants dispatched whilst vainly striving to escape to shore. The victims were first belaboured with oars, then fallen upon with tomahawks and finally beheaded, their heads being taken on board, and their bodies thrown to the sharks."

Mr. Brooke, whose words are thus quoted, says that in the course of two or three months in that one island alone he had

seen eighteen persons murdered in cold blood, and fifty taken away either by force or under false pretences.

If any one think such references too discursive for an Address to the members of a Society belonging to a country on the shores of the ocean on which such atrocities as have been mentioned have been committed, let me explain that I have considered them not altogether intrusive in a discourse to Christian gentlemen; and with one further remark I will conclude.

It is said that France intends to take possession of Santa Cruz. If it be so, and the intention be to civilize and christianise its population, well and good: but it would, I think, be a more suitable occupation if England (putting aside all political or territorial considerations) undertook the task of carrying her enterprise in colonization into effect by endeavouring to reclaim the savages of the Archipelagoes which have, by martyrdoms and massacres innumerable of British subjects, given her the responsibility as well as the prestige of furthering the cause of peace and evangelization; and I doubt not that those deaths which we have deplored will eventually lead as it were to the opening of a new vista in the dark prospects of Melanesian heathendom. It cannot be beyond the good wishes of ourselves, who belong to a Society which derives its title, by permission, from the Sovereign, who is again by the will of the nation styled "Defender of the Faith," to desire that Her Majesty may enrol among her subjects thousands snatched from slavery and emancipated from the dominion of rites and customs that have no other support than ignorance, brutality, and the worst passions of mankind.

SOCIETY'S WORK.

The work done by the Society during the last year is represented by the following list of contributions:—

May 12.—Anniversary Address, on Deep Sea Soundings, and the Geology of New Caledonia. By Rev. W. B. Clarke, M.A., F.G.S.

June 2.—Facts in American Mining. By S. L. Bensusan, Esq.

July 7.—On the Stanniferous Deposits of Tasmania. By S. H. Wintle, Esq. [Communicated by Rev. W. B. Clarke.]

August 7.—On Sydney Water Supply by Gravitation. By James Manning, Esq.

September 1.—Appendix to the preceding.

October 6.—Second paper on Supply by Gravitation. By James Manning, Esq.

November 3.—Scientific Notes in America and Europe. By H. C. Russell, Esq., F.R.A.S.

December 1.—Supplementary Notice on Deep Sea Soundings. By Rev. W. B. Clarke, M.A., F.G.S.

In the instance of our last volume, the delay that has unavoidably occurred in its publication is to be regretted, as it is an improvement on former volumes, containing the Proceedings of our monthly meetings, and two additional papers—one by our active Secretary, Professor Liversidge, on New South Wales Minerals, of which the title was read 9th December, 1874; and another, by Mr. Russell, our Treasurer, being a summary of the Meteorological Observations of the year. These will supply many extra pages to the work. The cause of delay in the completion of the volume is the accumulation of work in the Printing Office, so that others who share with us the good services of that Office have to wait as well as ourselves.

There is an evil in delays of the kind, which is unintended and unavoidable. In the present day, first publication of any new fact gives the right of priority as a discovery. By the kindness of the proprietors of the *Herald* we have been able to prevent any ill effect of the kind arising from irregularity of issue of our Transactions, so far as the authors of papers are concerned; but the members generally have to wait very long for the volumes after they are ready for the Press, owing altogether to the increased amount of business. This is one of many grounds for the desire expressed by numerous persons that a Copyright Act should be passed through Parliament. As the law now is, there is nothing to prevent any unscrupulous person from pirating the opinions or discoveries of living authors, and by skilful use of their words, whilst *omitting all marks of quotation or reference to names*, appropriating what is not their own, and altering

materials so purloined. I speak on this point with some authority, as I have myself suffered in this way; and were not our time too short, I could point out some cases where this species of "picking and stealing" has been a bar to the imparting of further information on matters interesting to the community.

CONCLUSION.

I have now completed my intention with respect to the materials of this Address. At first, I had proposed to introduce several notices of subjects which though of great interest I have seen fit to leave for other occasions. Allow me, however, to repeat that the chief points which require the Society's attention have reference to our progress.

There are those who have predicted that this Society will die out. At present it is not moribund but alive and active, and if those who ought to join us as working members would only lend us a helping hand I do not fear that we shall not realize the hopes of the most sanguine of us. Why should any of our members refuse to tell us, as briefly as they like, what may be useful to be known? In the arrangement proposed all kinds of information could be employed by the Sectional Committees without disturbing the modesty of the most retiring contributor; and why a mechanic, or a manufacturer, or a traveller, or mere observer, should keep back under some delicacy of feeling which hinders a common object I know not. We are called, no doubt, by a somewhat lofty designation, but we do not presume to consider ourselves of such renown as to make it presumption in any one to do what he can to help on the common work. We do not boast at present of taking a lead in Science or Literature, and if such were the aim of our Association I for one would retire from it at once. Our true position is that of pioneers, sowers, foundation-layers; and in that respect we have assuredly an honorable occupation; and as such, and such only, I have aspired to take a part, somewhat, perchance, too prominent, in occasionally "going-a-head," sometimes scattering a seed for thought here and there—and sometimes adding a pebble to what here-

after will, I hope, see itself surmounted by a superstructure of enduring reputation, when you and I shall have long passed away beyond the heats of controversy or the coldness of criticism. Let us do what we can to serve honestly our day and generation; and then we may be assured, that though posterity cannot benefit or hurt us now, in its own time it will do us justice. What more do we need?

May I be permitted to add that to myself it has been a great satisfaction to have contributed in what I know to be a humble way to the Society's work; and if I have done anything whatever to keep it on the move, such care as I have been enabled to bestow upon it has been amply rewarded by the kind co-operation of my friends in the Council during the many long years in which you have been pleased to place and keep me in a responsible position, and by an unexpected and general act of attention and regard not long since, which I should be wanting in duty and respect towards you if I did not thus publicly acknowledge.

Year by year, as I have occupied my accustomed place at your meetings, I have felt that I am less and less able to keep up with my own wishes for the advancement of the Society; and with frequent remindings that this is not my final resting-place, with a certainty also that I ought soon to make way for one younger and stronger than myself, I would now make what may be a final appeal as to the necessity of giving earnest consideration to the suggestions made at the beginning of this Address.

If all that remains of me at any future Anniversary be the painted canvas which does so much credit to the artist whom you voluntarily employed to do me honor, I still hope that that representation of me may look down upon a flourishing Association of men, whose appearance at your meetings will not be the mere inducement to spend a pleasant evening, but who will find that even such a gathering is to be a pledge that they have at heart a better aim and a more useful and nobler object for the employment of their leisure. I say not this in a presuming or in a doubting spirit; but I honestly desire to see the Royal Society

prosperous and happy in keeping up some show of great actual usefulness to the community to which we belong. And after I shall have ceased to weary some of you with these dissertations, it will, I hope, be your privilege to listen to a higher order of comment, and one better suited to command the attention of a scientific audience.

NOTES ON SOME REMARKABLE ERRORS SHOWN BY THERMOMETERS.

By H. C. Russell, B.A., F.R.A.S., Government Astronomer.

[*Read before the Royal Society of N.S.W.*, 7 *June*, 1876.]

In the present day, when so much reliance is placed on thermometers both by scientific and medical men, probably no apology is necessary for bringing before the members of the Royal Society the faults of one or two instruments, when, as in the present case, those faults seem to be quite inexplicable by known conditions affecting the accuracy of thermometers, and to depend upon some unknown relation existing between the mercury and the glass.

I therefore put the following facts on record, in the hope that they may yet be found to be connected with the explanation of some of the extraordinary temperatures that have been published.

For more than five years we have had a first-class dry and wet bulb hygrometer in use at the Observatory; by the side of the dry bulb a standard thermometer has been kept, and always read at the same time as the dry bulb. The difference between them varied very little, two or three tenths of a degree usually, and in some rare cases as much as one degree. Up to the 26th February, this year, we never had reason to suspect the dry bulb of uncertain indications; on that day the maximum temperature rose to 96·4 at or about noon; at 3 p.m., the dry bulb and standard had both fallen to 83·7, and at 9 p.m. to 68·9 and 69·0; next morning they read 69·6 and 69·8, but the following morning the readings were—standard, 64·9; dry bulb, 87·3; showing a difference of 22·4. It was at once inferred that the glass had cracked and let in the air, but as no crack could be seen on careful examination, and it was determined to continue observing it for a time. The observations will be found in Appendix A.

If a glass thermometer cracks, the mercury steadily rises till the tube is full, and it was expected that such would be the case here; but no, the difference steadily *decreased*, and in 35 days it had almost recovered its original condition, being sometimes less than half a degree; between the 7th and 17th of April the

difference increased to 13·3 degrees, and then fell again. On the 3rd May, and again on the 7th of May, two sudden jumps occurred, and the difference rose to 13·7. Since then it has gradually fallen, except a slight rise May 21, 22. (*See diagram.*)

In the first instance the barometer was steady at about 30 inches, with some minor oscillations, and there has been no barometric oscillation during the whole time which might be supposed equal to produce such effects, and even if there had been, it should have affected all the thermometers alike. At present I can see no satisfactory clue to the explanation of these thermometer excursions. Once before when using a standard, in April 1872, to test another thermometer, the temperature of the water was raised to 210°, and it was found that subsequently, for four days, the standard itself read too low by several tenths of a degree (see Appendix B), and then recovered its normal condition. Here the cause was evident; the glass had expanded, and did not *contract* as fast as it *cooled*. We often find differences also in the readings given by thermometers of known good quality, but these are attributed to difference in sensitiveness arising from thickness of glass, or other causes; where the changes are sudden, as in thermometers on the grass exposed to the effects of radiation, the differences sometimes amount to several degrees. (See Appendix C.) That common thermometers give results differing by several, and in some cases as much as ten degrees, is well known to all who have had much to do with them, and that the glass continues to contract for years after it has been melted is beyond question; for the makers keep thermometers two or three years before graduating them, and even then in many cases they go on contracting. But all the thermometers about which I have made these notes are of the best description, and the comparisons made in England before they were sent out have not been taken without re-examination. All the thermometers we use are compared in air with the standard here.

On examination with the microscope, the dry bulb in question presents two features which must be mentioned; one is a small piece of coloured glass as if lead had been reduced in melting the bulb; the other is a little patch that looks like water inside the bulb. As the bulb is blown by the workman's lungs, this may be condensed water in the bulb, from that source. Whether this can have anything to do with its uncertain readings I do not know, but it is possible that some action may take place between mercury and water under a vacuum.

One other point must be mentioned. Fine glass, such as that used for lenses, if kept untouched for some months and then examined with a microscope, will be found covered with oily-looking specks, which evidently ooze out of the glass, or are formed by the action of moisture on some of its constituents.

With regard to these thermometer changes, there have been found some very remarkable coincidences which should also be placed on record. The first jump in the thermometer was during the 27th of February. On that day at 2·30 p.m., we were visited by a small tidal wave, the result, it would seem, of earthquakes in New Zealand.

From 7th to 17th April we have the next remarkable part of the thermometer curve, and we have also many small tidal waves recorded about the same time.

On the 3rd of May we have the next conspicuous point in the curve, and on that day at 11·30 p.m., another tidal wave is recorded in Sydney and Newcastle, with many minor disturbances about the same time; and on the 7th of May we have the second in magnitude. On that day, at 6·45 p.m., another tidal wave reached Sydney, the result of earthquakes in New Zealand.

Again, on 21st of May, we have another feature in the thermometer curve, and another tidal wave recorded in Sydney harbour at 11·30 p.m. Are these coincidences accidental, or are they consequences of some impulse affecting all alike?

In the diagram the straight line represents the readings of the standard thermometer, reduced to a straight line. The curved line shows the difference between the dry bulb and the standard. At 9 a.m. on each day the gradual decrease in the difference shown day after day in so marked a manner is evident in all the readings, the differences being less at night than in the morning; showing a steady decrease in the gas or other substance in the thermometer which produced the difference.

Sydney Observatory, 7th June, 1876.

A

Readings of Standard and Dry Bulb Thermometers, Sydney Observatory, 1876.

Date.		Time.	Standard.	Dry bulb.	Difference.	Date.		Time.	Standard.	Dry bulb.	Difference.
Feb.	23	9 a.m.	67·7	67·9	0·2	March	9	9 a.m.	73·8	82·7	8·9
"	"	3 p.m.	70·1	70·2	0·1	"	"	3 p.m.	76·8	85·4	8·6
"	"	9 "	64·8	64·8	0·0	"	"	9 "	72·3	81·0	8·7
"	24	9 a.m.	72·1	72·1	0·0	"	10	9 a.m.	74·6	82·8	8·2
"	"	3 p.m.	74·3	74·3	0·0	"	"	3 p.m.	77·8	85·6	7·8
"	"	9 "	69·7	70·0	0·3	"	"	9 "	73·0	81·0	8·0
"	25	9 a.m.	77·3	77·5	0·2	"	11	9 a.m.	75·6	83·2	7·6
"	"	3 p.m.	84·0	84·0	0·0	"	"	3 p.m.	78·3	85·4	7·1
"	"	9 "	75·0	75·0	0·0	"	"	9 "	73·0	80·4	7·4
"	26	9 a.m.	79·4	79·5	0·1	"	12	9 a.m.	76·5	83·8	7·3
"	"	3 p.m.	83·7	83·7	0·0	"	"	3 p.m.	"	"	"
"	"	9 "	68·9	69·0	0·1	"	"	9 "	"	"	"
"	27	9 a.m.	69·6	69·8	0·2	"	13	9 a.m.	77·6	83·8	6·2
"	"	3 p.m.	"	"	"	"	"	3 p.m.	78·5	84·3	5·8
"	"	9 "	"	"	"	"	"	9 "	72·9	78·8	5·9
"	28	9 a.m.	64·9	87·3	22·4	"	14	9 a.m.	76·9	82·0	5·1
"	"	3 p.m.	69·2	90·3	21·1	"	"	3 p.m.	76·1	81·3	5·2
"	"	9 "	63·6	84·1	20·5	"	"	9 "	73·8	79·0	5·2
"	29	9 a.m.	66·3	85·5	19·2	"	15	9 a.m.	78·8	83·4	4·6
"	"	3 p.m.	69·9	88·3	18·4	"	"	3 p.m.	77·7	82·4	4·7
"	"	9 "	64·9	83·1	18·2	"	"	9 "	73·3	78·1	4·8
March	1	9 a.m.	68·6	85·9	17·3	"	16	9 a.m.	77·0	81·6	4·6
"	"	3 p.m.	71·6	88·0	16·4	"	"	3 p.m.	78·4	82·4	4·0
"	"	9 "	67·9	84·3	16·4	"	"	9 "	71·4	75·8	4·4
"	2	9 a.m.	70·0	85·8	15·8	"	17	9 a.m.	65·0	69·2	4·2
"	"	3 p.m.	72·5	87·9	15·4	"	"	3 p.m.	69·0	72·9	3·9
"	"	9 "	70·0	85·2	15·2	"	"	9 "	66·0	70·0	4·0
"	3	9 a.m.	75·2	89·7	14·5	"	18	9 a.m.	66·0	69·4	3·4
"	"	3 p.m.	74·5	88·6	14·1	"	"	3 p.m.	72·2	75·7	3·5
"	"	9 "	71·2	85·2	14·0	"	"	9 "	66·3	69·8	3·5
"	4	9 a.m.	74·0	87·3	13·3	"	19	9 a.m.	70·0	73·1	3·1
"	"	3 p.m.	74·7	87·9	13·2	"	"	3 p.m.	"	"	"
"	"	9 "	68·0	81·0	13·0	"	"	9 "	"	"	"
"	5	9 a.m.	71·0	83·2	12·2	"	20	9 a.m.	72·8	75·6	2·8
"	"	3 p.m.	"	"	"	"	"	3 p.m.	73·2	76·0	3·2
"	"	9 "	"	"	"	"	"	9 "	68·5	71·4	2·9
"	6	9 a.m.	71·1	82·9	11·8	"	21	9 a.m.	74·2	76·7	2·5
"	"	3 p.m.	75·3	86·6	11·3	"	"	3 p.m.	77·6	79·6	2·0
"	"	9 "	70·0	81·1	11·1	"	"	9 "	70·6	73·0	2·4
"	7	9 a.m.	74·0	84·4	10·4	"	22	9 a.m.	68·0	70·0	2·2
"	"	3 p.m.	75·8	85·9	10·1	"	"	3 p.m.	69·4	71·2	1·8
"	"	9 "	71·7	82·0	10·3	"	"	9 "	67·0	69·0	2·0
"	8	9 a.m.	75·0	84·7	9·7	"	23	9 a.m.	67·7	69·0	1·3
"	"	3 p.m.	76·2	85·6	9·4	"	"	3 p.m.	73·1	74·8	1·7
"	"	9 "	72·0	81·3	9·3	"	"	9 "	70·1	71·8	1·7

READINGS—*continued.*

Date.		Time.	Standard.	Dry bulb.	Difference.	Date.		Time.	Standard.	Dry bulb.	Difference.
March	24	9 a.m.	73·0	74·5	1·5	April	9	9 a.m.	60·8	61·7	0·9
,,	,,	3 p.m.	81·9	83·2	1·3	,,	,,	3 p.m.	,,	,,	,,
,,	,,	9 ,,	77·8	79·3	1·5	,,	,,	9 ,,	,,	,,	,,
,,	25	9 a.m.	77·8	78·9	1·1	,,	10	9 a.m.	64·2	65·3	1·1
,,	,,	3 p.m.	82·5	83·4	0·9	,,	,,	3 p.m.	65·8	66·8	1·0
,,	,,	9 ,,	81·2	82·6	1·4	,,	,,	9 ,,	58·5	59·0	0·5
,,	26	9 a.m.	82·3	83·1	0·8	,,	11	9 a.m.	57·3	59·1	1·8
,,	,,	3 p.m.	,,	,,	,,	,,	,,	3 p.m.	66·4	68·0	1·6
,,	,,	9 ,,	,,	,,	,,	,,	,,	9 ,,	63·8	65·3	1·5
,,	27	9 a.m.	69·4	70·1	0·7	,,	12	9 a.m.	61·2	63·2	2·0
,,	,,	3 p.m.	70·7	71·3	0·6	,,	,,	3 p.m.	65·0	66·6	1·6
,,	,,	9 ,,	67·2	68·0	0·8	,,	,,	9 ,,	62·1	64·0	1·9
,,	28	9 a.m.	67·7	68·8	1·1	,,	13	9 a.m.	63·9	67·0	3·1
,,	,,	3 p.m.	72·1	72·9	0·8	,,	,,	3 p.m.	65·0	67·6	2·6
,,	,,	9 ,,	68·2	69·3	1·1	,,	,,	9 ,,	63·0	66·3	3·3
,,	29	9 a.m.	65·7	66·6	0·9	,,	14	9 a.m.	67·4	70·4	3·0
,,	,,	3 p.m.	71·7	72·5	0·8	,,	,,	3 p.m.	,,	,,	,,
,,	,,	9 ,,	69·3	70·3	1·0	,,	,,	9 ,,	,,	,,	,,
,,	30	9 a.m.	70·0	70·8	0·8	,,	15	9 a.m.	64·7	66·7	2·0
,,	,,	3 p.m.	77·0	77·8	0·8	,,	,,	3 p.m.	71·0	73·0	2·0
,,	,,	9 ,,	63·0	63·9	0·9	,,	,,	9 ,,	65·0	67·0	2·0
,,	31	9 a.m.	60·8	61·2	0·4	,,	16	9 a.m.	62·2	64·9	2·7
,,	,,	3 p.m.	74·3	75·0	0·7	,,	,,	3 p.m.	,,	,,	,,
,,	,,	9 ,,	64·8	65·6	0·8	,,	,,	9 ,,	,,	,,	,,
April	1	9 a.m.	65·2	65·7	0·5	,,	17	9 a.m.	63·2	65·0	1·8
,,	,,	3 p.m.	71·0	71·5	0·5	,,	,,	3 p.m.	65·7	67·6	1·9
,,	,,	9 ,,	63·5	64·2	0·7	,,	,,	9 ,,	59·7	61·0	1·3
,,	2	9 a.m.	65·2	65·8	0·6	,,	18	9 a.m.	57·3	58·5	1·2
,,	,,	3 p.m.	,,	,,	,,	,,	,,	3 p.m.	68·7	70·0	1·3
,,	,,	9 ,,	,,	,,	,,	,,	,,	9 ,,	64·7	66·3	1·6
,,	3	9 a.m.	63·8	64·2	0·4	,,	19	9 a.m.	60·0	61·0	1·0
,,	,,	3 p.m.	71·8	72·5	0·7	,,	,,	3 p.m.	69·7	71·7	2·0
,,	,,	9 ,,	66·0	67·2	1·2	,,	,,	9 ,,	61·6	62·6	1·0
,,	4	9 a.m.	67·0	68·0	1·0	,,	20	9 a.m.	60·0	61·0	1·0
,,	,,	3 p.m.	75·8	76·5	0·7	,,	,,	3 p.m.	75·5	76·5	1·0
,,	,,	9 ,,	70·7	71·4	0·7	,,	,,	9 ,,	68·0	69·0	1·0
,,	5	9 a.m.	77·0	77·8	0·8	,,	21	9 a.m.	67·9	68·8	0·9
,,	,,	3 p.m.	85·0	85·6	0·6	,,	,,	3 p.m.	75·5	76·4	0·9
,,	,,	9 ,,	71·6	72·2	0·6	,,	,,	9 ,,	68·0	69·0	1·0
,,	6	9 a.m.	67·5	68·0	0·5	,,	22	9 a.m.	64·3	65·6	1·3
,,	,,	3 p.m.	73·8	74·3	0·5	,,	,,	3 p.m.	77·2	78·9	1·7
,,	,,	9 ,,	66·2	67·0	0·8	,,	,,	9 ,,	67·0	68·2	1·2
,,	7	9 a.m.	67·6	68·5	0·9	,,	23	9 a.m.	61·9	62·8	0·9
,,	,,	3 p.m.	74·0	75·0	1·0	,,	,,	3 p.m.	,,	,,	,,
,,	,,	9 ,,	65·2	66·2	1·0	,,	,,	9 ,,	,,	,,	,,
,,	8	9 a.m.	64·8	65·2	0·4	,,	24	9 a.m.	61·5	62·4	0·9
,,	,,	3 p.m.	66·0	66·9	0·9	,,	,,	3 p.m.	69·0	70·0	1·0
,,	,,	9 ,,	56·0	56·8	0·8	,,	,,	9 ,,	64·1	65·2	1·1

READINGS—*continued.*

Date.	Time.	Standard.	Dry bulb.	Difference.	Date.	Time.	Standard.	Dry bulb.	Difference.
April 25	9 a.m.	60·8	62·0	1·2	May 11	9 a.m.	60·5	67·2	6·7
" "	3 p.m.	74·2	75·2	1·0	" "	3 p.m.	69·0	75·7	6·7
" "	9 "	67·8	69·0	1·2	" "	9 "	66·5	73·2	6·7
" 26	9 a.m.	63·7	64·8	1·1	" 12	9 a.m.	68·0	74·5	6·5
" "	3 p.m.	66·5	67·6	1·1	" "	3 p.m.	73·7	79·9	6·2
" "	9 "	64·1	65·6	1·5	" "	9 "	66·0	72·0	6·0
" 27	9 a.m.	62·2	63·0	0·8	" 13	9 a.m.	59·0	64·6	5·6
" "	3 p.m.	69·5	70·5	1·0	" "	3 p.m.	66·8	72·7	5·9
" "	9 "	65·8	66·9	1·1	" "	9 "	59·7	65·5	5·8
" 28	9 a.m.	63·0	64·6	1·6	" 14	9 a.m.	53·0	58·5	5·5
" "	3 p.m.	77·6	79·0	1·4	" "	3 p.m.	"	"	"
" "	9 "	67·3	68·4	1·1	" "	9 "	"	"	"
" 29	9 a.m.	58·9	59·8	0·9	" 15	9 a.m.	53·8	59·0	5·2
" "	3 p.m.	68·0	69·0	1·0	" "	3 p.m.	57·6	62·8	5·2
" "	9 "	61·2	62·3	1·1	" "	9 "	55·8	60·9	5·1
" 30	9 a.m.	58·0	58·9	0·9	" 16	9 a.m.	53·2	58·5	5·3
" "	3 p.m.	"	"	"	" "	3 p.m.	61·2	66·0	5·2
" "	9 "	"	"	"	" "	9 "	54·7	59·4	4·7
May 1	9 a.m.	57·3	58·2	0·9	" 17	9 a.m.	53·5	58·0	4·5
" "	3 p.m.	60·2	61·2	1·0	" "	3 p.m.	59·0	63·5	4·5
" "	9 "	59·5	60·9	1·4	" "	9 "	56·3	61·0	5·3
" 2	9 a.m.	56·9	57·9	1·0	" 18	9 a.m.	55·6	59·8	4·2
" "	3 p.m.	67·0	68·0	1·0	" "	3 p.m.	61·0	65·2	4·2
" "	9 "	62·0	63·0	1·0	" "	9 "	57·2	61·2	4·0
" 3	9 a.m.	56·4	57·5	1·1	" 19	9 a.m.	55·9	59·9	4·0
" "	3 p.m.	68·2	69·3	1·1	" "	3 p.m.	59·2	63·0	3·8
" "	9 "	63·7	64·7	1·0	" "	9 "	58·0	62·0	4·0
" 4	9 a.m.	58·0	63·8	5·8	" 20	9 a.m.	57·0	60·9	3·9
" "	3 p.m.	64·5	70·2	5·7	" "	3 p.m.	59·2	63·3	4·1
" "	9 "	62·6	68·2	5·6	" "	9 "	60·1	64·0	3·9
" 5	9 a.m.	58·8	63·7	4·9	" 21	9 a.m.	59·0	63·2	4·2
" "	3 p.m.	64·8	69·7	4·9	" "	3 p.m.	"	"	"
" "	9 "	61·1	65·9	4·8	" "	9 "	"	"	"
" 6	9 a.m.	61·0	65·0	4·0	" 22	9 a.m.	60·4	65·0	4·6
" "	3 p.m.	62·5	66·8	4·3	" "	3 p.m.	64·0	68·3	4·3
" "	9 "	61·5	65·8	4·3	" "	9 "	60·6	64·8	4·2
" 7	9 a.m.	61·9	66·4	4·5	" 23	9 a.m.	58·4	62·9	4·5
" "	3 p.m.	"	"	"	" "	3 p.m.	66·9	71·2	4·3
" "	9 "	"	"	"	" "	9 "	57·9	61·9	4·0
" 8	9 a.m.	58·7	71·0	13·7	" 24	9 a.m.	56·3	60·0	3·7
" "	3 p.m.	63·6	72·9	9·3	" "	3 p.m.	64·7	68·3	3·6
" "	9 "	58·7	67·7	9·0	" "	9 "	59·2	62·5	3·3
" 9	9 a.m.	57·2	65·8	8·6	" 25	9 a.m.	53·6	56·8	3·2
" "	3 p.m.	68·0	76·4	8·4	" "	3 p.m.	64·0	67·3	3·3
" "	9 "	60·2	68·3	8·1	" "	9 "	56·5	59·4	2·9
" 10	9 a.m.	56·5	64·0	7·5	" 26	9 a.m.	53·5	56·4	2·9
" "	3 p.m.	67·9	70·2	2·3	" "	3 p.m.	62·2	65·0	2·8
" "	9 "	63·0	70·4	7·4	" "	9 "	61·4	64·0	2·6

READINGS—*continued*.

Date.		Time.	Standard.	Dry bulb.	Difference.	Date.		Time.	Standard.	Dry bulb.	Difference.
May	27	9 a.m.	60·2	62·7	2·5	June	4	9 a.m.	48·0	49·0	1·0
„	„	3 p.m.	60·1	62·3	2·2	„	„	3 p.m.	„	„	„
„	„	9 „	62·3	64·8	2·5	„	„	9 „	„	„	„
„	28	9 a.m.	62·2	64·4	2·2	„	5	9 a.m.	48·8	49·9	1·1
„	„	3 p.m.	„	„	„	„	„	3 p.m.	60·0	61·3	1·3
„	„	9 „	„	„	„	„	„	9 „	54·7	56·0	1·3
„	29	9 a.m.	56·6	58·4	1·8	„	6	9 a.m.	51·3	52·5	1·2
„	„	3 p.m.	62·0	64·0	2·0	„	„	3 p.m.	53·9	55·3	1·4
„	„	9 „	63·1	65·2	2·1	„	„	9 „			
„	30	9 a.m.	61·5	63·5	2·0	„	7	9 a.m.			
„	„	3 p.m.	61·0	62·6	1·6	„	„	3 p.m.			
„	„	9 „	60·4	62·3	1·9	„	„	9 „			
„	31	9 a.m.	54·7	56·2	1·5	„	8	9 a.m.			
„	„	3 p.m.	59·1	60·7	1·6	„	„	3 p.m.			
„	„	9 „	52·8	54·4	1·6	„	„	9 „			
June	1	9 a.m.	53·0	54·5	1·5	„	9	9 a.m.			
„	„	3 p.m.	60·4	62·0	1·6	„	„	3 p.m.			
„	„	9 „	54·8	56·2	1·4	„	„	9 „			
„	2	9 a.m.	56·0	57·4	1·4	„	10	9 a.m.			
„	„	3 p.m.	63·0	64·4	1·4	„	„	3 p.m.			
„	„	9 „	53·2	54·6	1·4	„	„	9 „			
„	3	9 a.m.	48·9	50·0	1·1	„	11	9 a.m.			
„	„	3 p.m.	58·3	59·9	1·6	„	„	3 p.m.			
„	„	9 „	50·4	51·7	1·3	„	„	9 „			

B.

READINGS of Standard and Dry Bulb Thermometers, Sydney Observatory, 1872.

Date.	Time.	Standard.	Dry Bulb.	Difference.
April 18	9 a.m.	62·5	62·6	0·1
„ „	3 p.m.	67·0	67·1	0·1
„ „	9 „	62·4	62·7	0·3
„ 19	9 a.m.	60·1	60·3	0·2
„ „	3 p.m.	66·1	67·2	1·1
„ „	9 „	61·1	62·0	0·9
„ 20	9 a.m.	58·7	59·5	0·8
„ „	3 p.m.	66·5	67·2	0·7
„ „	9 „	62·6	63·0	0·4
„ 21	9 a.m.	63·5	64·2	0·7
„ „	3 p.m.	„	„	„
„ „	9 „	„	„	„
„ 22	9 a.m.	55·1	55·5	0·4
„ „	3 p.m.	64·0	64·0	0·0
„ „	9 „	55·0	55·1	0·1

C.

READINGS of Minimum Thermometers on the grass corrected for index errors.*

Date.	1	Difference 1—2.	2	3	Difference 3—2.
May 26	42·0	0·3	42·3	46·9	4·9
„ 27	55·7	3·2	52·5	53·3	0·8
„ 28	54·5	3·5	51·0	55·2	4·2
„ 29	51·0	3·3	47·7	51·9	4·2
„ 30	52·0	3·1	48·9	53·2	4·3
„ 31	46·5	3·4	43·1	47·6	4·5
June 1	37·5	3·4	34·1	38·7	4·6
„ 2	39·5	2·9	36·6	40·7	4·1
„ 3	37·3	3·5	33·8	38·7	4·9
„ 4	37·5	3·2	34·3	38·8	4·5
„ 5	39·9	3·4	36·5	41·3	4·8
„ 6	44·5	2·6	41·9	46·3	4·4
„ 7	45·0	3·9	41·1	45·4	4·3
Means	44·8	3·0	41·8	46·0	4·2

* Index errors in each case determined by comparison with the standard *in air*.
No. 1—Glass Thermometer on wooden stand.
No. 2—Glass Thermometer on zinc stand.
No. 3— Do. do.

ON THE ORIGIN AND MIGRATIONS OF THE POLYNESIAN NATION;

DEMONSTRATING THEIR ORIGINAL DISCOVERY AND PROGRESSIVE SETTLEMENT OF THE CONTINENT OF AMERICA.

By the Rev. Dr. Lang.

[*Read before the Royal Society of N.S.W.*, 5 *July*, 1876.]

In the outset of a series of lectures delivered before this Society seven or eight years since, I observed that the singular phenomenon which the South Sea Islands present to the eye of a philosophical observer is perhaps one of the most difficult to account for that has ever engaged the efforts or the ingenuity of man. From the Sandwich Islands in the Northern, to New Zealand in the Southern, Hemisphere; from the Indian Archipelago to Easter Island, adjoining the continent of America—an extent of ocean comprising sixty degrees of latitude and a hundred and twenty of longitude, that is exactly twice the extent of the Roman Empire in its greatest glory—the same primitive language is spoken, the same singular customs prevail, the same semi-barbarous nation inhabits the multitude of the isles.

In using this language, however, I would not be understood to include the numerous islands and groups of islands of the Western Pacific; the inhabitants of which are all remarkably different from the other South Sea Islanders, and would seem to be derived from the same primitive stock as the aborigines of Australia and the Papuans of New Guinea. These islanders of the Western Pacific are all of a much darker hue than those of Polynesia Proper, or the Eastern Islanders, many of them being jet black; and there is this remarkable distinction between the two races, that while the languages of Eastern Polynesia are all mere dialects of the same primitive tongue, there is an infinity of languages in the islands of Western Polynesia, and all remarkably different from each other, every island of any size having one of its own, and the larger islands three or four.

My attention was strongly directed to this very interesting subject at an early period after my arrival in this Colony for the first time in the year 1823; and as there was a more frequent intercourse at that period than in later years, between New South

Wales and certain groups of islands in the Pacific, I employed myself as I could from time to time in investigating the manners and customs of the islanders generally and the modes and causes of their migrations from island to island, and in endeavouring, if possible, to ascertain from what part of the surrounding world they originally came.

The Polynesians, like all other islanders, are a maritime people, very frequently if not constantly at sea, and ever and anon making short voyages from island to island in their respective groups. Now although the trade winds in the Pacific are remarkably regular, they are not so uniformly. Sudden and violent westerly gales arise from time to time, and when these are contrary to the course of the unfortunate islander, passing perhaps from one well-known island to another, he may be driven out to sea, notwithstanding all his efforts to the contrary, and may never regain his native isle. In such cases, unless he happens to be cast on some previously unknown island, he will at length be engulphed in the waves. This then is the first of the ways in which the numberless islands of the Pacific Ocean have been successively peopled, in the course of ages past, at a cost of human life and suffering absolutely appalling to think of. The second of the modes in which the numberless groups of the Pacific Ocean have been successively peopled in past ages is from the event of war. In all past time the islands of the Pacific have been the scene of almost perpetual and savage warfare; and it has often happened that the vanquished party have been obliged to trust themselves in their canoes to the mercy of the winds and waves, and the chance of being cast upon some unknown island, rather than remain in their native island to be butchered wholesale by their victors. This has in all likelihood been the origin of cannibalism in the South Sea Islands, the wretched survivors in these uncertain and perilous voyages being compelled from sheer necessity to kill and prey upon one another ere they could reach, if they ever did, any land. The state of things I have thus pourtrayed accounts for another and remarkable fact in Polynesian history, viz., the absence of any distinction of caste among the natives of the New Zealand group of islands, while in the Tonga or Friendly Islands, which the vicinity and the resemblance of language in these groups would indicate as the original home of the New Zealand race, there is a full development of caste. For in whatever manner the original forefathers of New Zealand had left Tonga, their supposed native isle, all of the lower castes would be mercilessly butchered one by one for the subsistence of the rest, and the whole of the original inhabitants of their new found land would thus be Rangatiras or gentlemen. The spirit of adventure, which in many cases has been remarkably developed among the South Sea Islanders, must also have tended strongly to the spread of mankind over the number-

less isles of the Pacific. At all events, since the islands of the Pacific were first known to civilized men, there have been numerous instances of all these modes—by accident, by the event of war, and by the spirit of adventure—of carrying population to the most distant islands. The captain of the vessel in which I made my first voyage from Sydney to England, in the year 1824, having previously been the master of a whaler in the Pacific, told me that on one occasion he happened to fall in with a canoe with a number of natives on board who had accidentally been driven to sea by a sudden gale, and having nearly expended all their provisions, were utterly unable to find their way back to their native isle. The benevolent shipmaster took them all on board his vessel and supplied them with the necessary food for their subsistence. But as it would have taken him about three hundred miles out of his proper course to carry them to their native island, he merely gave them a compass, and showing them how to use it he left them to pursue their homeward voyage themselves. In due time the summits of the mountains of Tahiti, their native isle, hove in sight, and the natives leaped and danced for joy at sight of them in their canoe. Then looking first at the land and then at the compass, their mysterious guide, which they supposed alive, they exclaimed, "The cunning little thing—it saw it all the time!"

The next question before us is from what portion of the habitable globe has the Polynesian race been derived, and with what other family or tribe of the earth's inhabitants does it exhibit any affinity?

Before attempting to answer this question, I would observe that there are certain writers who maintain that the Polynesians could not possibly have come from the westward or the continent of Asia, from the prevalence of the easterly or trade winds of both hemispheres. De Zuniga, a Spanish writer of some celebrity, and the author of a history of the Philippine Islands, in which he held office under the Spanish Government, maintains that the Polynesians could never have made their way across the Pacific from the westward, in consequence of the uniform prevalence of the easterly trade winds in that ocean. He therefore advances the singular hypothesis that the South Sea Islands were originally peopled from America, and alleges in proof of it the remarkable resemblance of the language of the American Indians of Chili, of which certain specimens were contained in the history of that country by the Spanish historian Erçilla, to that of Tagala in the Philippine Islands; forgetting that the natives of continents are never maritime people like those of islands, and not taking into consideration the obvious fact that even if the American Indians had been disposed to maritime adventure, they might have made thousands of voyages from the west coast of America ere ever they could hit upon any one of the Islands of the Pacific, the nearest of

which is at least 2,000 miles from the American land. But this testimony of that eminent navigator La Perouse is decisive against the hypothesis of De Zuniga. "Westerly winds," says that distinguished navigator, "are at least as prevalent as those from the eastward in the vicinity of the equator, in a zone of 7 or 8 degrees north and south; and they" (that is the winds in the equatorial regions) "are so variable that it is very little more difficult to make a voyage to the eastward than to the westward." To the same effect Captain (afterwards Admiral) Hunter, R.N., the second Governor of New South Wales, observes in the narrative of his voyage from Port Jackson to Batavia, in the year 1791, "It was very clear to me, from the winds we had experienced since we came to the northward of the line, that at this time of the year (the end of July), and generally during the height of the north-west monsoon in the China seas, these (westerly) winds do sometimes extend far to the eastward of the Philippine Islands, and frequently blow in very heavy gales."

Having thus disposed of the preliminary objection as to the alleged impossibility of getting to the eastward in the Pacific Ocean, I observe that the Polynesian race exhibits the clearest evidence of an Asiatic origin.

First,—In the distinction of caste, which, as I have already observed, although not existing in New Zealand, for the reason I have mentioned, was as clearly developed in the Friendly Islands as it ever was in India.

Secondly,—In the singular institution of Taboo, which obtains universally in the South Sea Islands, and is evidently also of Asiatic origin. The word *Taboo* corresponds pretty nearly with the Latin *sacer* or the Greek *αναθεμα*, the person, place, or thing under *taboo*, being what the Latins would call *sacer diis cœlestibus*, holy or sacred to the celestial gods, or *sacer diis infernis*, accursed or devoted to the infernal gods. It may be difficult indeed to account for so singular an institution as the Polynesian taboo; but its Asiatic origin is evident and unquestionable. Its influence and operation may be traced from the Straits of Malacca, across the whole Continent of Asia, to the Sea of Tiberias and the Isles of Greece. In Ionia, in Hindostan, and in Tahiti, the person, the place, or the thing that was subjected to the influence of the mysterious *taboo* was, in the words of the Latin historian, *auguriis patrum, et prisca formidine sacrum*, abstracted from the common usages of life, by a superstitious dread, the result of ancient religious observances.

Thirdly,—Numerous Asiatic customs and observances are practised in the South Sea Islands, as well as in the Indian Archipelago, which closely adjoins the Continent of Asia, and must therefore have been originally peopled from that continent. Of these, however, our time will only allow me to mention one,

but a very remarkable one—I mean the filthy practice of chewing the areca nut or *piper betel*, so prevalent in the East Indies—a practice which makes the mouth unnaturally red and the teeth black. This Asiatic practice was observed by Captain Hunter among the natives of the Duke of York's Island to the eastward of New Ireland; and by Captain Hovell, of the "Young Australian," among the inhabitants of Banks' Island, still further east, or in 170° west longitude.

Fourthly,—The evidence of language in regard to the origin of the South Sea Islands is still stronger and less open to objection. "Language," says the celebrated Horne Tooke, "cannot lie, and from the language of every nation we may with certainty collect its origin."

"One original language," observes Sir Stamford Raffles, "seems in a very remote period to have pervaded the whole Indian Archipelago, and to have spread (perhaps with the population) towards Madagascar on one side and the islands in the South Seas on the other." And in confirmation of this idea, Mr. Marsden, the author of a history of Sumatra, and an eminent authority in all matters connected with the Indian Archipelago, informs us that "upon analysing a list of thirty-five Malayan words, of the simplest and most genuine character, twenty will be found to correspond with the Polynesian generally, seven with a small portion of the dialects of the South Seas, and seven, as far as our present knowledge extends with the Malayan itself."

There is another very remarkable fact, under the head of language, which I shall merely mention for the present, as I shall have to refer to it more particularly in the sequel, and which proves incontestibly the original identity of the Polynesian race with the Indo-Chinese nations of South-eastern Asia and the inhabitants of the Indian Archipelago; for in common with these nations the Polynesians, in the islands in which their social system was more fully developed, as in the Tonga or Friendly Islands, as compared with New Zealand, there was a language of ceremony or deference distinct altogether from the language of common life. My idea therefore is, that the forefathers of the Polynesian race were somehow struck off from the other or Malayan tribes of the Indian Archipelago at so early a period in the history of mankind as within five hundred years after the deluge, according to the Hebrew chronology, and that in the course of many successive generations, and under the influence of those occasional westerly gales that prevail in the Pacific, they had crossed that ocean to the eastward, within the Equatorial belt of La Perouse if not rather considerably to the northward, according to our very able Member, Mr. Edward Hill, from their supposed starting point in the Philippine Islands, to Pasquas or Easter Island, in latitude 27° in the Southern Pacific, within

2,000 miles of the American land. There, at all events, our own great navigator, Captain Cook, actually found not only a people of the real Polynesian type but the colossal remains of their long extinct civilization.

And this extreme antiquity which I assign to the Polynesian race is not merely a matter of conjecture. There are two remarkable notes of time in the case that throw us back irresistibly to the very *cunabula gentis*, the actual cradle of the Polynesian race. The distinguished scholars of the Indian Archipelago—Sir Thomas Raffles, Dr. Leyden, Mr. Crawford, Mr. Marsden, and others—inform us that there have been two distinct foreign infusions into the ancient Malayan tongue, viz., an Arabic infusion co-eval with the era of Mahomet and the Mahometan invasion of the East. Now, of this copious Arabic infusion in the Malayan language, which may be dated as high as the seventh century of our era, there is no trace in the Polynesian tongue—a circumstance which proves incontestibly that the Polynesian race had been struck off from the Malayan tribes of the Indian Archipelago before the era of Mahomet. But there is another and much more ancient foreign infusion in the Malayan language, of which also there is no trace in the Polynesian dialect, I mean the Sanscrit infusion. This, therefore, throws back into the very highest antiquity the origin of the Polynesian race as a distinct family of mankind.

To retrace our steps for a moment, we have now established the important fact, that under the influence of causes that are still in operation throughout the South Sea Islands, the Polynesian race has spread itself in the course of long ages past over the whole extent of the Pacific Ocean—from the Sandwich Islands in the northern to New Zealand in the southern hemisphere, and from the western shores of the Pacific, to Easter Island, within 1,800 or at the utmost 2,000 miles of the American land.

At the time when I was earnestly pursuing my investigations into the origin and migrations of the Polynesian race, I was myself crossing the Pacific, on my second voyage from Sydney to London, in the year 1830, having carried with me to sea for the express purpose, such works bearing on the subject as I could then procure in the Colony. We had encountered on that occasion a strong southerly gale of seven days continuance after rounding the North Cape of New Zealand; and for part of that time we had the mountains of that island clearly in sight. We then got a strong westerly gale that carried us the whole way right across the Pacific to Cape Horn, with close-reefed topsails, at the rate of ten or eleven knots an hour. In these circumstances, when reading De Zuniga's work, in which he tells us that the aboriginal languages of Tagala, in the Philippines, and of Araucania, in Chili, were remarkably similar

(*bastante conformes*), and alleges the fact as a reason for his strange hypothesis, that the South Sea Islands were peopled from America; it struck me all at once and with prodigious force, when glancing, as I could not help doing at the moment, at the possible results to which the suggestion might lead, that the converse of the Spaniard's hypothesis might perhaps be the true idea in the case, and that instead of Easter Island having been colonized and settled from America, some unfortunate canoe suddenly blown off from that island by some such violent westerly gale as the one before which we were then careering over the great waters of the Pacific, might have landed the first cargo of human beings on the continent of America.

It would seem indeed as if Easter Island had been placed in its actual position by the all wise and beneficent Creator for the express purpose which in all likelihood no other island in the Pacific could have served—of ensuring the discovery and settlement of that great continent by the Polynesian race—of proving, so to speak, a stepping stone between Polynesia and America. Situated, as that island is, in 27 degrees south latitude, that is, well up in the south temperate zone, and very nearly in the latitude of the city of Brisbane, on this coast, it is equally beyond the influence of the south-easterly trade winds of the intertropical regions, and within the full sweep of the strong westerly gales of the southern Pacific. Such gales as the one I experienced in the year 1830—and I have experienced various others of the same kind in subsequent voyages across the Pacific—such a gale as I have referred to would certainly extend as far north as Easter Island; and, once caught within its resistless sweep, the hapless Polynesian craft would be driven before it, in all likelihood in less than ten days, to the American land. And where is it supposable that a Polynesian vessel would in such circumstances reach the American continent? Why, the westerly gale I have supposed would admit of no deviation from a due easterly course, either northward or southward, in the case of any hapless vessel accidentally brought within its power. Such a vessel would therefore reach the unknown land to the eastward, as nearly as possible in the latitude of Easter Island—that is, somewhere near the present seaport town of Copiapo, in the Republic of Chili. That, I am confident, was the place where the American continent was first trodden by the foot of man.

I am happy to be able to state in this stage of our inquiry that an able and scientific member of this Society, Mr. Edward Hill—who is eminently qualified for offering a reliable opinion on the subject of our present investigations, from having himself spent not less than four years in traversing the Pacific Ocean in all directions, and especially from having made the origin and migrations of the Polynesian nation his particular study for

many years past—has assured me that he coincides entirely with me in the views I have stated both in regard to the origin of the Polynesian nation in the Indian Archipelago and to the courses which the individuals of that nation must have taken in crossing the Pacific in the regions of its greatest breadth from their starting point in the Philippine Islands to Pasquas or Easter Island, which he reckons is situated 2,200 miles from the American land. There he leaves me, however, not from any doubt as to my being then on the right track for ascertaining how both North and South America were originally peopled, but because he had never entertained the thought of following the Polynesians across the intervening tract of ocean that separates Easter Island from the mainland of America.

Taking it for granted, therefore, for the sake of argument, that that continent was originally reached by a canoe full of Polynesians, who had been accidentally blown off the land from Easter Island by one of those sudden, violent, and protracted westerly gales that prevail at certain seasons in the southern Pacific, and had crossed the intervening breadth of ocean to the American land, somewhere near Copiapo, in the Republic of Chili, what would be the result of these unfortunates finding themselves in their new-found-land? Why, like all emigrants from the old world to some colonial field beyond seas, they would just reproduce in their new settlement the whole framework of society on the model on which it was constructed in their native isle. They would practice the same manners and customs as had obtained in their fatherland, and they would construct both their private habitations and their public buildings on the same plan or model to which they had been accustomed in the land of their nativity.

Now, this is precisely what we find to have been the result of the supposed original discovery of America by a handful of famished Polynesians at a very early period in the history of mankind. We find the whole framework of society among the aborigines of America constructed on precisely the same model as in Polynesia; we find the same singular manners and customs prevalent in both cases; and we find those wonderful remains of an extinct civilization in America that excite the astonishment of modern civilization, of precisely the same character and aspect as if they had been erected by a Polynesian architect.

Reserving the proof of this for the present, I would now present the Society with a brief statement of the theories put forth by a great variety of authorities in regard to the origin of the Indians of America, in the recent work of an eminent American historian, Mr. Bancroft, entitled "The Native Races of the Pacific States of North America." Before doing so, however, I would lay down as a test for judging and deciding on all

such theories the principle established by the great philosopher and traveller, Humboldt, and confirmed and strengthened by other two very eminent authorities on this subject—Dr. Morton, of Philadelphia, and Dr. Von Martius, of Bavaria.

What then is the testimony of that eminent philosopher and keen observer, Baron Humboldt, on the subject of the aborigines of America? Why, it is as follows:—"The nations of America, except those which border on the Polar circle, *form a single race*, characterised by the form of the skull, the colour of the skin, the extreme thinness of the beard, and straight, glossy hair."*

And again, "I think I discover, in the mythology of the Americans, in the style of their paintings, in their languages, and especially in their external conformation, the descendants of a race of men, which, early separated from the rest of mankind, has followed for a lengthened series of ages a peculiar road in the unfolding of its intellectual faculties, and in its tendency towards civilization."†

Dr. Morton, of Philadelphia, with whom I spent an evening in his own house in that city, in the year 1840, was the author of a scientific work of the highest character,‡ entitled "Crania Americana," containing accurate drawings of the *crania* of all the aboriginal races of that continent, from the Esquimaux region in the far north to Cape Horn. Having heard very shortly before of a Professor in the German University of Freiburg maintaining very dogmatically that the Azteck conquerors and the comparatively civilized builders of the pyramids and the other wonderful ruins in America were a totally different race from the wild Indians of the forest of the present day, Dr. Morton assured me that there was no difference in the skulls of the aborigines, that they were all one people, the descendants of one common stock, one nation, and on asking him to what section of the human family the Indo-Americans bore the greatest resemblance in their craniological development, he replied at once—the Polynesian.

I shall be reminded, however, that the Indo-American nations of Peru and Mexico were in a comparatively high state of civilization at the period of the Spanish conquest. When America was first discovered and colonized by Europeans, the western equatorial regions of that continent were the seat of extensive, flourishing, and powerful empires, the inhabitants of which were well acquainted with the science of government, and had made no inconsiderable progress in the arts of civilization. At the time when the institution of posts was unknown in Europe it

* Humboldt's Researches, vol. i, p. 15.

† *Ibid.*, p. 200.

‡ Dr. Morton had quoted in his great work a work of mine published in London in 1834, on the subject of this paper.

was in full operation in the Empire of Mexico; at a time when a public highway was either a relic of Roman greatness or a sort of nonentity in England, there were roads of 1,500 miles in length in the Empire of Peru. The feudal system was as firmly established in these transatlantic kingdoms as in France, and the system of etiquette that regulated the intercourse of the different ranks of society, was as complete and as much respected as in the Court of Philip the Second. The Peruvians were ignorant of the art of forming an arch, but they had constructed suspension bridges across frightful ravines; they had no implements of iron; but their forefathers could move blocks of stone as huge as the Sphinxes and the Memnons of Egypt. The Mexicans were unacquainted with the art of forming cast metal pipes, but they had constructed dykes or causeways as compact as those of Holland; and their capital, which was situated in the centre of a salt water lake, was supplied with a copious stream of fresh water, brought from beyond the lake in an aqueduct of baked clay. They had had no Cadmus to give them an alphabet, but their picture writing enabled them to preserve the memory of past events and to transmit it to posterity.

"The Indigenous race of the New World," observes Dr. Von Martius, an eminent Bavarian philosopher, who travelled in the Brazils during the earlier portion of the present century, "is distinguished from all the other nations of the earth, externally by peculiarities of make, but still more internally by their state of mind and intellect. The aboriginal American is at once in the incapacity of infancy and unpliancy of old age; he unites the opposite poles of intellectual life." And again, "The first germs of development of the human race in America can be sought nowhere except in that quarter of the globe.* In short, Humboldt, Dr. Morton, of Philadelphia, and Dr. Von Martius, all give it as their deliberate opinion that the aborigines of America are all, with the exception of the Esquimaux of the Polar circle, one people, and unlike every other people on the face of the earth. But while both Humboldt and Dr. Morton modestly decline pronouncing any judgment as to their origin, Dr. Von Martius, in the true spirit of modern scepticism, tells us at once that they had sprung into existence on the spot.

To return now to Mr. Bancroft, although that writer lays down no theory of his own as to the original peopling of America, he evidently inclines to the opinion of those who derive the Indo-Americans from Eastern Asia by Behring's Straits. "The theory that America was peopled," says Mr. Bancroft, "or at least, partly peopled, from Eastern Asia, is certainly more widely advocated than any other, and in my opinion is moreover

* Von dem Rechtzustande unter der Ureinwohnern Braziliens. A paper by Dr. Von Martius, in the Royal Geographical Society's Journal, vol. ii.

based upon a more reasonable and logical foundation than any other."* But in so far as the emigration from Eastern Asia is supposed to have taken place by Behring's Straits or the Alieutian Islands, the objection taken to such a theory by the Quarterly Review (vol. xxi., pp. 334–5), is unanswerable: "We can hardly suppose that any of the pastoral hordes of Tartars would emigrate across the strait of Behring or the Alieutian Islands without carrying with them a supply of those cattle on which their whole subsistence depended." To suppose indeed that a people like the Tartars of North-eastern Asia, who live, so to speak, on horseback, and subsist almost entirely on the flesh and milk of their flocks and herds, would cross that narrow strait, either by water or on the ice when frozen, without carrying with them a single horse, a single sheep, or a single head of cattle, is quite incredible. And to talk of an extensive emigration of the Tartar nations of North-eastern Asia flying to America from before the warlike hosts of Zenghis Khan, how could a non-maritime people have crossed the intervening tract of ocean between Asia and America? or if they did, how did they come to leave all their sheep, cattle, and horses behind? But if America was first peopled, as I have supposed, by a handful of famished Polynesians, who had been suddenly driven to sea from Easter Island, and carried across the intervening ocean to America, somewhere near Copiapo in the State of Chili, in South America, the entire absence of all our domestic animals at the era of the Spanish conquest was the necessary consequence of the manner in which they had originally reached their new-found-land.

"Analogies," says Mr. Bancroft, "have been found, or thought to exist between the languages of several of the American tribes and that of the Chinese; but it is to Mexico, Central America, and Peru, and not to the north-western coast, where we should naturally expect to find them most evident."† Besides, in the important item of architecture, in which we should have expected some proofs of identity between the Chinese and the Polynesians, if there had been any original affinity between these nations, there is none whatever. Speaking of the ruins of Central America, Stephens says: "If their (the Chinese) ancient architecture is the same with their modern, it bears no resemblance whatever to these unknown ruins." Central America, vol. ii. p. 438.

It would be a mere waste of time to take into serious consideration the claims which Mr. Bancroft shows us have been put forth by various writers to the discovery and settlement of America on behalf of the Egyptians, the Phœnicians or Tyrians, and the Carthaginians. It would be inexcusable, however, to omit all men-

* The native races of the Pacific States of North America, vol. i, p. 30.
† Bancroft. *Ibid.*

tion of those that have been preferred for the Jews in general or the Ten Lost Tribes in particular. There are four principal writers on this subject, viz., Garcia, a Spaniard; Lord Kingsborough, an enthusiastic Englishman; and a Dr. Boudinot, an American divine, of Huguenot descent; but none of these writers give us any rational idea as to how the Jews could ever have crossed the Pacific, or any proof of the identity of the Indo-Americans with the Jewish people, while the far-fetched and strained analogies on which they base their theory are evidently the mere offspring of a warm imagination. If my theory as to the origin of the Polynesian nation is well founded (as I am confident it is), that nation must in all likelihood have taken its departure from the Indian Archipelago as early as the age of Abraham himself, and long before the Jews became a nation at all, and in this opinion I am not singular.

"Much," says Mr. Bancroft, "has been written to prove that the north-western parts of America were discovered and peopled by Scandinavians long before the time of Columbus. Although a great part of the evidence upon which this belief rests is unsatisfactory, and mixed up with much that is vague and undoubtedly fabulous, yet it seems to be not entirely destitute of historical proof."

Again, "We come now," says Mr. Bancroft, "to the theory that the Americans, or at least part of them, are of Celtic origin," and then he gives us the legend of Madoc, a prince of Wales, having crossed over to America, as also the opinion of Lord Monboddo that America was colonized and settled by Scotch Highlanders who had left their language in the country in proof of it.

Mr. Bancroft then alludes to the story of Atlantis, "as old as Plato," that is, of a submerged lost land that once lay "to the west of Europe," by which it has been alleged emigrants from the old world had originally crossed over by dry land to America. But there are two things fatal to all these theories. 1st. That there is no reliable evidence whatever of either a Scandinavian, or a Welsh, or of any other emigration westward from the old world to America. The emigrants of all these countries died and left no sign, no progeny. But even if there had been any considerable emigration from Europe to America, the three eminent authorities I have quoted—Humboldt, Dr. Morton, and Dr. Von Martius—assure us that the Indo-Americans could never have descended from any people of the old world, there being no other nation upon earth with which they have the slightest affinity.

"Hence it is," says Mr. Bancroft, "many not unreasonably assume that the Americans are autochthones (or created on the spot) until there is some good ground given for believing them to be of exotic origin."* Now this is the very desideratum I

* *Ibid*, 131.

propose to supply, by giving the best possible grounds for believing that the Indo-Americans are not *autochthones* or indigenous, but are intimately related, in the way of natural descent, to one of the most ancient sections of the family of man. I shall reserve the proof of this, however, for another paper.

Part II.

The points I have established in the previous part of my paper are:—

1. That the Polynesian nation, scattered as it is over the numberless islands of the vast Pacific Ocean, is of Asiatic origin and of Malayan race, and was separated from the rest of mankind at a period of the earliest antiquity in the history of man.

2. That under the operation of causes that are still in active operation in the Pacific Ocean, the forefathers of the Polynesian nation proceeded to the eastward from their original point of departure in the Indian Archipelago, and that their descendants in many successive ages and generations crossed the Pacific Ocean—discovering and occupying the numerous islands and groups of islands in their course, as well as others at great distances both north and south, till they reached their farthest east in Pasquas or Easter Island, within 2,000 miles of the American land.

3. That the same causes that had operated in carrying them to the eastward as far as Easter Island—a distance of not less than 7,000 or 8,000 miles—must have operated in carrying them still farther east, across the remaining tract of ocean from that island to somewhere near Copiapo, in the same latitude, in the Republic of Chili, in South America, where our own great navigator, Captain Cook, found them a hundred years since. And my theory is—

4. That from that landing-place they gradually proceeded northwards and eastwards during the numberless ages that have since elapsed; occupying and forming settlements in all eligible localities in their course, first in the southern and afterwards in the northern continent of America, as far as the Lakes of Canada and the coast of Labrador.

With this view I shall show you in the first place that the civilization of the more civilized Indo-American nations was exclusively Polynesian, and cast entirely in a Polynesian mould

I shall then show that the phenomena of language in America point directly to a Polynesian origin; and I shall conclude by showing that the same singular manners and customs prevail among the wild and uncivilized tribes of both nations.

I. The peculiar type of the civilization of the Indo-American nations is exhibited in some measure at least in the very remarkable architectural remains that are scattered in great profusion over both the American continents. These consist of pyramidal erections, of temples, of tumuli, and of fortifications. I have already observed that the pyramidal and colossal style of the architecture of the earlier postdiluvian nations was in all likelihood a relic of the civilization of the antediluvian world. There can be no doubt, however, of its universal prevalence in that early period of the history of our race; and wherever we can trace its existence we may rest assured that the civilization of which it is the sign was derived from the ages immediately succeeding the deluge. Now there is nothing more remarkable than the prevalence of this peculiar type of civilization, this pyramidal and colossal style of architecture, in the ruined cities of America. Humboldt, as I have already shown, compares those of Mexico with the pyramids of Egypt; and in all the recently-discovered ruins of Indo-American cities in Guatimala and Yucatan—in Copan, in Quirigua, in Palenque, and in Uxmal—pyramidal buildings are uniformly found, sometimes in great numbers, together with monolith statues, in some instances upwards of 20 feet high. "The pyramid of Papantla," says Humboldt, "is built entirely with hewn stones of an extraordinary size, and very beautifully and regularly shaped; three staircases lead to the top."* Stephens also, in his "Incidents of Travel in Central America," thus describes a ruin he had seen in the ancient Indo-American city of Copan in Guatimala: "This temple is an oblong enclosure. The front or river wall extends on a right line north and south 624 feet, and is from 60 to 90 feet in height. It is made of cut stones, from 3 to 6 feet in length, and a foot and a half in breadth. * * * The other three sides consist of ranges of steps and pyramidal structures, rising from 30 to 140 feet in height on the slope."† Now each of these remarkable buildings, to which there is nothing at all similar either in ancient or modern Europe, or even in Asia, consists of a pyramid with steps up to its top on three of its sides, while the fourth forms the wall for a temple enclosure. But the structure described, on the authority of Mr. Ellis—the temple and pyramid of Atehuru in Tahiti—is precisely of the same character, and might have been erected by the same architect from the same plan; while in Easter Island, the supposed point of departure from Polynesia to

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* Humboldt's Researches, i., 89.

† Stephens' Incidents of Travel in Central America, page 87.

America, there are monolith statues quite as large as those of Copan or Quirigua. Can we doubt then that the Polynesians and Indo-Americans are the same people, and that their forefathers carried with them across the vast Pacific and to both of the American continents, the peculiar type of civilization, photographed as it had been upon their minds, that characterised the ages immediately after the deluge?

There were, properly speaking, no such buildings as temples either in Polynesia or Indo-America—what we should call their temples being merely square or rather oblong spaces, enclosed with massive walls, but without roofs. It is observed by Mitford, in his History of Greece, that the antiquity of the writings of Homer may be inferred from his silence on the subject of temples and image-worship. They were both, it would seem, equally unknown to the ancient South Sea Islanders and Indo-Americans; although in later times, and in particular localities, idolatry obtained a footing and became prevalent among them. "The Indians of the forest," says Humboldt, "when they visit occasionally the missions, conceive with difficulty the idea of a temple or an image. 'These good people,' said the missionary, 'like only processions in the open air. When I last celebrated the patron festival of my village, that of San Antonio, the Indians of Inirida were present at mass. 'Your God,' said they to me, 'keeps himself shut up in a house as if he were old and infirm; ours is in the forest, in the fields, and on the mountains of Sipapu, whence the rains come.'"* The same magnificent idea of a great Spirit pervading the world is, as is well known, prevalent among the wild Indians of North America, who have neither temples nor images—a fact that would seem to indicate that the forefathers of their race in the Indian Archipelago had been separated from the rest of mankind, before the monstrous idolatries of the East had been devised, and when the purer theology of the age immediately succeeding the deluge still prevailed among men.

There is another indication of the hoary antiquity, as well as of the identity, of the Polynesian and Indo-American races in the want of mortar or cement of any kind in their more ancient buildings. This, it seems, was one of the characteristics of that pyramidal and colossal style of architecture that obtained in the ages immediately succeeding the deluge. The Rev. Dr. Porter, for some time a missionary in the East, and now a professor in the General Assembly's College in Belfast, Ireland, who, when stationed in Syria and Damascus, had visited and described the colossal remains of the giant cities of Bashan, to which he assigns an antiquity of not less than four thousand years, thus describes

* Humboldt's Narrative, vol. v., page 278.

one of the houses which he entered in one of these cities. "The house seemed to have undergone little change from the time its old master had left it; and yet the thick nitrous crust on the floor showed that it had been deserted for long ages. The walls were perfect, nearly 5 feet thick, built of large blocks of hewn stones, *without lime or cement of any kind.* The roof was formed of large slabs of the same black basalt, lying as regularly, and jointed as closely, as if the workmen had only just completed them. They measured 12 feet in length, 18 inches in breadth, and 6 inches in thickness."* Precisely similar is the account which the American, Herman Melville, gives of the colossal remains in the Marquesas Islands. "A series of vast terraces of stone rises step by step for a considerable distance up the hill side. These terraces cannot be less than 100 yards in length and 20 in width. Their magnitude, however, is less striking than the immense size of the blocks composing them. Some of the stones, of an oblong shape, are from 10 to 15 feet in length, and 5 or 6 feet thick. Their sides are quite smooth; but though square, and of pretty regular formation, they bear no mark of the chisel. They are laid together *without cement.*"† And in the account of the remarkable colossal remains in Easter Island, the same very singular circumstance is observable. "These monuments consist in a number of terraces or platforms built with stone, cut and fixed with great exactness and skill, forming, *though destitute of cement*, a strong durable pile. On these terraces are fixed colossal figures or busts. They appear to be monuments erected in memory of ancient kings or chiefs."‡ Although many of the South Sea Islands consist of vast masses of coral, and are surrounded with coral reefs, the natives never had in any instance learned the art of burning the coral into lime; and when taught the process by the missionaries, they testified alike their astonishment and delight. The colossal terraces, I may add, are exactly similar to those described and figured by Stephens in his account of the ruined Indo-American cities of Copan, Palenque, and Uxmal. I quite agree, however, with Mr. Stephens in regarding these cities as of a comparatively modern date, and as having been inhabited in all likelihood down to the era of the Spanish conquest; first, because there are wooden lintels still remaining in some of the ruinous buildings; and, secondly, because the walls are cemented with mortar, and covered with stucco. For in the more ancient buildings of that continent, as on the shores of the Lake Titicaca, in Peru, there is no cement used. Spanish writers describe the remains of an ancient Peruvian temple, con-

* The Giant Cities of Bashan; London, 1867, page 26.
† Typee, page 178.
‡ Ellis's Polynesian Researches, iii., 326.

sisting of an enclosed space, open at the top, of which the walls are about 12 feet in height, and consist of stones of an immense size, some of them being 30 feet long, 18 broad, and 6 feet thick. *These stones are not cemented with mortar;* neither have they been squared to join closely to each other, like hewn stones in a European building, although the stones of ancient Peruvian buildings are sometimes found hewn into regular forms; but cavities have been wrought with the utmost exactness, and with incredible labour, in one stone to receive the natural or accidental protuberances of another.

Tumuli, constructed, in some instances, of immense stones, and in others, as on the banks of the Ohio, of mounds of earth, are also found among the remains of ancient civilisation, both in the South Sea Islands and in America. I have already mentioned the tomb of Toobo Tooi, in the island of Tonga, constructed of immense stones that must have been rafted across the sea from some other island, as Tonga is a mere mass of coral, and perfectly flat.

Remains of ancient and regular fortifications have also been discovered in both continents of America; and the circumstance has repeatedly awakened much curiosity respecting the origin, the history, and the fate of the nation that has left behind it these memorials of its ancient civilisation. But regular fortifications of a similar kind are still met with in all parts of the South Sea Islands. In some islands they are constructed of walls of loose stones piled on each other on the tops of hills, as in New Zealand; in others, as in Ascension Island, in the Northern Pacific, of a wall of 30 feet high, enclosing a harbour, and formed of large blocks of dressed stone, built up with great architectural skill, but without cement of any kind; in others they are formed of strong palisades, like the Burman Stockades, as in the level island of Tonga; and in others still they consist of some artificial addition to a place of great natural strength, as in the district of Atehuru, in Tahiti. In short, the South Sea Islanders have evidently been in a sufficiently advanced state of civilisation to enable them to construct fortifications, and to adapt these fortifications, in regard to the materials employed in their construction, to the nature of the country in which they were required. This part of our subject is so very interesting that I shall willingly avail myself of the following passage from Mr. Ellis:—

"The fortress at Maeva, in Huahine," one of the Society Islands, "bordering on a lake of the same name, is probably the best artificial fortification in the islands. Being a square of about half a mile on each side, it encloses many acres of ground well stocked with breadfruit, containing several springs, and having within its precincts the principal temple of their tutelar

deity. The walls are of solid stonework, in height 12 feet. They are even and regularly paved at the top. On the top of the walls (which in some places were 10 or 12 feet thick) the warriors kept watch and slept. Their houses were built within, and it was considered sufficiently large to contain the whole of the population. There were four principal openings in the wall, at regular distances from each other, that in the west being called the King's road. They were designed for ingress and egress; but during a siege were built up with loose stones, when it was considered a *pari haabuoa*, an impregnable fortress."*

Considering that the normal state of the South Sea Islands has from time immemorial been that of civil or rather internecine war, there is no point of comparison between the Polynesians generally and the Indo-Americans more interesting than that of their fortifications. Those of the Indo-Americans appear to have been generally formed of mounds of earth—a mode of formation well adapted for such localities as the alluvial banks of the Ohio, the dead levels near the lakes of Canada, or the elevated plains of Central America, but not at all adapted for the South Sea Islands. My talented townsman, the late John Galt, Esq., of Greenock, Scotland, the author of a whole series of popular works of fiction about half a century ago, and father of the late Premier in Canada, has told me that he had seen the remains of an Indian fort on the summit of a precipitous ridge near Lake Simcoe, in Upper Canada. It consisted of a mound of earth, enclosing a considerable extent of ground; but on the banks of the Miamis River, much farther to the southward, the Indian forts had been constructed of stone.

Nay, the march of ancient civilisation among the Indo-Americans may even be traced, in some measure, by those most interesting remains. In South America I have not heard of their being found to the eastward of the Andes. The gloomy forests of Guiana and the Brazils were evidently unfavorable for the preservation of Indo-American civilisation; and the portion of the race that wandered into these vast solitudes was necessarily broken up, at an early period, into an infinity of insignificant tribes that could hold little or no communication with each other, and that, consequently, very soon sunk irrecoverably beneath the level of the rest of their nation. But the regions of Central America, the elevated plains of Bogota and Cundinamarca, the open valleys of Peru, and the lofty and secluded but highly fertile tracts of Chili, were much more favorable for the formation of powerful states and empires; and it is, accordingly in these portions of the continent of South America that the ruins of ancient cities and of extensive fortifications are found. In the North American continent, the course of the Mississippi and its tribu-

* Ellis: Polynesian Researches iv, 459.

tary streams would, doubtless, guide the Indian in his progress to the northward; and it is, accordingly, on the banks of the Ohio, in the Western prairies, and along the lakes of Canada, that we find the monuments of his ancient power.

There is therefore a remarkable similarity in the developments of civilisation in the article of national defences or fortifications, on the part of the Indo-American nations and the Polynesians respectively. One is constrained to regard them as the same people, exhibiting, as they do, in circumstances remarkably different, the same amount of intellectual power and mechanical ability. There are certainly no such palatial residences to be found in the South Sea Islands as those of which we find the ruins in the Indo-American cities of Central America and Yucatan. But the reason is obvious—the South Sea Islands afforded no such fields for the establishment of mighty empires, the exercise of kingly power, and the other developments of luxury, as there were in Mexico and Peru and Central America. But I maintain, without fear of contradiction, that there is nothing in the civilisation of these Indo-American empires of the past that is not fairly traceable to a Polynesian source.

II. I now proceed to the second branch of our subject—to show that the phenomena of language, and of what may be called literature among the aborigines of America, point directly to a Polynesian origin.

Taking it for granted, therefore, that the theory I have been endeavoring to establish, is well founded, and that America had been originally discovered by a handful of Polynesians from Easter Island, who had been caught suddenly, when perhaps fishing off the coast of that island in one of those violent westerly gales that are so prevalent in the Southern Pacific, and had been driven before the wind to the American land, what are the phenomena in regard to language which this theory would lead us to anticipate—supposing as I have done that the forefathers of the Indo-American race in both continents had landed on the west coast of South America, somewhere near Copiapo, in the Republic of Chili, and that the future migrations of their descendants, north, east, and south, had commenced from that point? Why, we should expect, as a matter of course, that the Polynesian character of the language or languages spoken by the Indo-American people would be retained the most strongly in the region in which the forefathers of the race had first landed. Now this is precisely what we find to be the actual fact. De Zuniga, the historian of the Philippine Islands, a most unexceptionable witness in such a case, informs us that the words of the language of the Araucanian Indians of Chili, contained in the work of Erçilla, the historian of that people, are strikingly conformable, *bastante conformes*, to those of the language of Tagala, one of the districts of the

Philippines. I may add, in passing, that one of our own respected members, Mr. Edward Hill, who spent four years of his life in sailing among the South Sea Islands, and who knows, perhaps, more about their inhabitants than any other person in this Colony, while he coincides with me entirely in regarding these islanders as Malays from the Indian Archipelago, conceives that the Philippine Islands were their starting point from that Archipelago, and that, to use the nautical language, they made their easting in the Northern hemisphere, but in that Equatorial belt, in which La Perouse and Admiral Hunter inform us that at certain seasons of the year westerly winds are as prevalent as easterly.

We should also expect if my theory is well founded, that the Indian languages of South America generally, down to the Equator, would exhibit much more of the Polynesian and vocalic character than those of the northern continent, the latter being so much farther from the original point of departure. And this is precisely what we find in fact. Whole strings of words in the language of the Indians of the British province of Guiana, whole strings of words in the language of the Cuna Indians of the Isthmus of Darien, are in their form and character precisely like so many words in the Polynesian dialects of New Zealand and Tahiti.

A scholar, accustomed to trace the affinities, or to detect the radical dissimilarity of different languages, would at once unhesitatingly assert that the following words of the dialect of the Warows, of British Guiana, were just so many words of the Polynesian tongue:—

Head	Magaah	Water	Ho
Eyes	Maamu	Earth	Hotah
Mouth	Maroho	Sun	Yah
Hair	Maaheo	Moon	Waanehah
Ears	Mahohoko	Stars	Keorah
Arms	Mahaara	Thunder	Nahaa
Skin	Mahoro	Rain	Naahaa
Blood	Hotuh	Paddle	Haahah

The following words are from the dialect of New Zealand:—

Mahana	Day	Madino	Smooth
Marama	The moon	Maha	Much
Maripi	A sword	Matapo	Blind

N.B.—The syllable Ma, in both lists, is in all likelihood a prefix.

The following Indian names of localities on the Demerara River, supplied me by a friend returned to England from Demerara, have also quite a Polynesian aspect:—Arigaraboe, Hiagua, Haboe, Boera-boera-wa, Warawarau, Maraka, Mamaa, Moenetari, Mari Mari, Winipio, Mamikoeroa, Toematamatia, Motolca, Akyma, Kaiwalia, Kamakaiaha, Dalawila, Wai, or Vai, is the Polyne-

sian word for water; and Waridu, Waratili, Walaba, are the names of three creeks that empty themselves into the Demerara River.

The following specimens of the language of the Cunas, one of the tribes of Indians inhabiting the Isthmus of Darien, have also very much of a Polynesian aspect. I extract it from "The Journal of the Royal Geographical Society for the year 1868," page 100.

Father	Tata
Mother	Nana
	Nusatileli Nana, Nusatileli's mother
Brother	Urpa
Sister	Orne
Son	Hilu
Man, or men	Tule
Water	Ti
Canoe	Ulu. Look to the canoes—Ulutaque
Paddle	Canie. Take care of the paddles—Canie pehue taki.
Black	Rati
Red	Kiniti
High	Tumati
Ill, evil	Chuli
I, me	Anu
You, thou	Pe
Day	Yppa
Evening	Sueto
Rice	Aro
Flesh	Sána
Needle	Ico, yco
Bench, seat	Cána
Dish, plate	Náala
Calabash	Noga
Yes	Ee (nasal)
No, nothing	Chúle
Who	Ipi
Where, when	Pia mai
To take	Káe
To see	Take
To have	Nica
What have you?	Ipi pe nica
To tell	Shogue. Tell him—Pe shogue.
To know	Huishi
To go	Nae. Go (imper.), Pe nae.
Pain	Nun maké
One	Kuasak
Two	Pagua

Three	Pa
Four	Pake
Five	Atal
Six	Nerkua
Seven	Kugule
Eight	Pavaga
Nine	Pakewake

De Zuniga also observes, in the passage of his work which I have already quoted, that "the proper names of places, about the middle of the continent of South America, are very similar to those of the Philippines."

The following are a few of these names of places in South America having a Polynesian aspect:—Peru, Quito (Kito), Guatimala (Katimala), Arica, Loa, Titicaca, Panama, Huayna, Chili, Caicara, (Kaikara), Alahualpa, Tiahuanacu, Arequipa (Arekipa), Guarohiri (Karohiri), Huanuco, Lima, Tarapaca, Guana Xato (Kanahato), &c. The same Polynesian character of the language also holds in regard to persons even in Mexico. For example, the Mexican reverential affix *tzin* or *azin*, which was always added to the names of princes, is in all likelihood the Indo-Chinese affix, *asyane*, signifying lord, if not rather the Chinese word *tsin*. In the list of Mexican kings who reigned previous to the era of the Spanish conquest we find the names of Nopal-tzin, Ho-tzin, Quina-tzin (Kina-tzin), Cacoma-tzin, Cuicuitzca-tzin, Coanaco-tzin, Montezuma-tzin, Guatimozin (Ka-Tima-tzin). Several of these proper names have a remarkable resemblance to modern Polynesian names; the last especially—the name of the unfortunate prince whom the Spaniards extended over a fire of coals to compel him to inform them where he had hidden his treasures—that name is, when stripped of its Spanish doublet and its reverential affix, a pure New Zealand name.

When we reach the northern continent, however, in which the movement of nations, wars, and conquests would seem to have been much more frequent than in the South, the Polynesian or vocalic character of the language disappears, and we meet with combinations of consonants of a really formidable character, altogether unlike the speech of Polynesia. The Aztecks, or modern Mexicans, who had overrun the Mexican territory from the northward, and whose tenth king, Montezuma, was the reigning monarch at the era of the Spanish invasion, ascribed the erection of the famous pyramid of Teotihuacan to the Toltecks, a tribe of kindred origin and language, who had also overrun Mexico, five hundred years before the Azteck conquest; but they did so simply because their chronology, which, like that of many other conquering tribes, overlooked the records and traditions of the vanquished people, did not extend any higher than the era of the migration and conquests of the northern tribes.

But the probability is that the pyramid of Teotihuacan was erected long before the Toltecks had emerged from the forests of the North, and that that warlike but less polished race retained the ancient Polynesian name of the stupendous edifice, while they worshipped their own national divinities within its sacred precincts, under their own northern appellations. At all events there is a wonderful difference in character and aspect between the Polynesian name Teotihuacan and those of the Azteck and Tolteck divinities *Huitzilopochtli*, the god of war, and *Mictlancihuatl*, the goddess of hell.

I have already quoted the strongly expressed opinion both of Humboldt and of Dr. Von Martius, that the Indo-Americans are all one and the same people, from north to south, with no intermixture with any other portion of the family of man. Baron Humboldt also apprises us of the very interesting fact that notwithstanding the wonderful diversity of language among the aborigines of America there is a common principle of mechanism exhibited in the structure of all the aboriginal languages of that great continent which entitles us to refer them all to one common origin. "Languages," says that illustrious writer, "are much more strongly characterized by their structure and grammatical forms than by the analogy of their sounds and of their roots; and this analogy of sounds is sometimes so disfigured in the different dialects of the same tongue as not to be distinguishable; for the tribes into which a nation is divided often designate the same object by words altogether heterogeneous. Hence it follows that we are easily mistaken, if, neglecting the study of the inflections, and consulting only the roots—for instance, the words which designate the moon, sky, water, and earth—we decide on the absolute difference of two idioms from the simple want o resemblance in sounds."* "From the country of the Esquimaux to the banks of the Oroonoko, and again from these torrid banks to the frozen climate of the Straits of Magellan, mother-tongues, entirely different with regard to their roots, have, if we may use the expression, the same physiognomy. Striking analogies of grammatical construction are acknowledged, not only in the more perfect languages, as that of the Incas, the Tymara, the Guarani, the Mexican, and the Cora, but also in languages extremely rude. Idioms, the roots of which do not resemble each other more than the roots of the Sclavonian and the Biscayan, have those resemblances of internal mechanism which are found in the Sanscrit, the Persian, the Greek, and the German languages. It is on account of this general analogy of structure—it is because American languages, which have no word in common (the Mexican, for instance, and the Quichua), resemble each other by their organization, and form complete contrasts with the languages of

* Humboldt, *ubi supra.*

Latin Europe, that the Indians of the missions familiarise themselves more easily with an American idiom than with that of the metropolis. In the forests of the Oroonoko I have heard the wildest Indians speak two or three tongues. Savages of different nations often communicate their ideas to each other by an idiom which is not their own."*

Another extraordinary coincidence in the civilisation of the Indo-Americans with that of Polynesia presents itself in the fact of there having been in both a language of ceremony, distinct from the language of common life. I have shown in my first lecture that there was such a language, not only among the Indo-Chinese nations of Eastern Asia, but in Polynesia also, especially in the larger islands and among the more advanced tribes, as in Samoa and Tahiti; as, for instance, when inferiors addressed their superiors, when a plebeian addressed a chief, or when the latter addressed his prince. This language of ceremony did not consist in the use of a few phrases of deference and respect, such as those in use in European languages, in addressing royalty or nobility. It constituted, so to speak, a separate language, and pervaded the whole economy of speech. "The Mexicans," says Dr. Robertson, when alluding to the singular circumstance, which he had no idea of its having ever obtained or been observed among any other people,—"The Mexicans had not only reverential nouns, but reverential verbs;" and the use of any other than this reverential language in conversing with a king or higher chief would, both in Mexico and in Tahiti, have been held tantamount to high treason. This feature of resemblance between such widely dissevered portions of the human family is surely of such a character as not to be mistaken for a mere accidental coincidence; it constitutes rather an evidence of the absolute identity of the Indo-American and Polynesian nations that cannot be gainsaid.

The right of property was recognised and established among the Indo-American nations; but the lower orders generally cultivated a considerable extent of ground in common, the produce of which was laid up in storehouses, called *tambos*, and distributed at certain periods, agreeably to some established custom. Now it is very remarkable that the practice of the New Zealanders was precisely similar. The kumaras, or sweet potatoes of that island, are always cultivated *pro bono publico* by persons set apart for the purpose; the produce being afterwards distributed according to rule. The storehouses in New Zealand are always *taboo*, the violation of which by any person is death. I suspect the Spaniards have either reported the word inaccurately, or disguised it a little with their peculiar pronunciation; for the Mexican *tambo* is unquestionably the same word as the Polynesian *taboo*, as they both signify the same thing.

* Humboldt, *ubi supra*.

Perhaps, however, the most remarkable feature in the civilisation of the Indo-American nations was their picture writing and their hieroglyphics; by which they were enabled to transmit to posterity a knowledge of the memorable events of successive ages. The progress made by the Mexicans in these arts of a higher civilisation was truly wonderful, and the long columns of hieroglyphics carved in stone on their colossal monuments, and resembling in some measure the hieroglyphics of ancient Egypt, carry us back, as almost everything else does in Indo-American civilisation, to the remotest period in the history of man. Unfortunately there has as yet been no Champollion, as in Egypt—no Rawlinson, as in Assyria—to interpret these wonderful remains of an extinct civilisation; but although there are no such remains as the picture writing of the ancient Mexicans in the South Sea Islands, it is quite evident that the Polynesians were on the right track towards the much higher level of the chroniclers and the picture writers of Mexico, and that all that was wanting for the development of their idea was a suitable field, which the comparatively narrow limits of the South Sea Islands and their small population did not present. "Along the southern coast of the Island of Hawaii," says Mr. Ellis in his Polynesian Researches, "both on the east and west sides, we frequently saw a number of straight lines, semi-circles, or concentric rings, with some rude imitations of the human figure, cut or carved in the compact rocks of lava. They did not appear to have been cut with an iron instrument, but with a stone hatchet, or a stone less frangible than the rock on which they were pourtrayed. On inquiry, we found that they had been made by former travellers, from a motive similar to that which induces a person to carve his initials on a stone or tree, or a traveller to record his name in an album—to inform his successors that he has been there. When there were a number of concentric circles with a dot or mark in the centre, the dot signified a man, and the number of rings the number of the party who had circumambulated the island. When there was a ring, and a number of marks it denoted the same, the number of marks showing of how many the party consisted, and the ring, that they had travelled completely round the island; but when there was only a semicircle it denoted that they had returned after reaching the place where it was made."

I am inclined to differ from Mr. Ellis when he regards these rude specimens of picture writing as the first efforts of an uncivilised people towards the construction of a language of symbols. I am inclined to regard them, in common with those colossal remains of the architecture of the earlier Polynesians, which their degenerate offspring of the present day can only behold with amazement, rather as the scanty but interesting relics of an ancient and primitive civilisation, of which both the

memory and the evidences have almost passed away. In short, it appears to me incontestible that the practice of picture writing was in general use among the earliest inhabitants of the South Sea Islands; but that in the course of exterminating wars, or rather in consequence of that rust which gathers over the human mind when it is cooped up within a narrow sphere, and thereby loses the edge and the polish which it acquires by being frequently rubbed upon the whetstone of society, this and various other Asiatic arts were gradually lost.

It is natural, however, to suppose that the impression which had once been made upon the Polynesian mind, but which had thus been well nigh effaced, from the causes I have enumerated, in the South Sea Islands would again be revived and deepened on the plains of Quito, and around the Lake of Mexico; just as a writing in sympathetic ink becomes darker and more distinct when held close to the fire.

The Indian nations of North America had carried this, as well as the other arts, and the general civilisation of its central regions, as high as the lakes of Canada. When that province was colonised by the French the most powerful Indian nation in North America was the Iroquois—a nation which it afterwards required many a fierce battle to exterminate. That warlike nation was sufficiently civilised at the period I refer to, to practise the Mexican art of picture-writing; for an Indian village, situated somewhere near the site of the present city of Montreal, having about that period been surprised and destroyed by the French, a painting or picture-writing, which afterwards fell into the hands of the French, containing a hieroglyphical representation of the event, was executed by some Indian artist, to transmit an account of it either to the distant tribes of the nation or to posterity. The village was indicated by a series of wigwams, and the state in which its inhabitants were surprised, by an Indian asleep. The rising sun indicated that the attack had taken place at the break of day; and the moon in her first quarter on the back of a stag, afforded the additional information that it had taken place in the early part of that month in the Indian year of which the stag was the emblem.

In a letter to the Secretary of the Antiquarian Society, published in the sixth volume of the Archæologia, W. Bray, Esq., gives an account of an Indian picture-writing which had been intended to commemorate the exploits of Wingenund, an Indian warrior of the Delaware nation, about the middle of last century. It consisted of a series of marks or characters inscribed within a square figure on a sugar-maple tree on the Muskingham River, in the State of Delaware. The first line consisted of the figure of a turtle—the emblem of the tribe to which the warrior belonged—an arbitrary mark designating the particular chief who had

executed the writing, and a representation of the sun. Ten horizontal lines on the right side of the figure denoted the number of expeditions in which the warrior had been engaged; and opposite to each of these lines on the left there was a series of marks resembling the letter X, with a bar across the top of it, representing the number of scalps or of prisoners he had taken; the sex of the victim being designated by a slight variation of the character, and the central part of the figure being occupied with a rude drawing of three different British forts which he had attacked on these occasions. At the bottom of the figure there were twenty-three vertical lines inclining a little to the left (the figure of the sun in the first line of the writing being at the right side of the painting) to denote that at the time the record was left the writer was marching on another expedition to the northward.

So far north, even, as the Hudson's Bay Territory, this method of communication by picture-writing prevails among the wild Indians of that inhospitable region. The Rev. John West, one of the Hudson's Bay Company's chaplains, on travelling in the Red River colony in the year 1820, came up with an Indian family who proposed accompanying him to the factory. "The Indian had two sons, who, he said, were gone in the pursuit of a deer; and on quitting the encampment to travel with us he would leave some signs for them to follow us on their return. They were drawn upon a broad piece of wood which he prepared with an axe. They were—1st. A tent struck to intimate that the party had gone forward in a particular direction; 2nd. Four rude figures indicating the number of the party, and exhibiting by their dress and accoutrements the rank or condition of each individual, viz., a European chief, a European servant, and Indian attendant, and the two Indians from the encampment. 3rd. A curvilinear figure with the two extremities of the curve pointing towards the hindermost of the figures, to intimate to the Indian's two sons that they were to follow the party." *

The development of this rude method of communication into the famous picture-writing of Mexico was a natural process to be expected in the progress of society in the large wealthy capital of a great empire like that of Montezuma.

The same remark holds good also in regard to the astronomical knowledge exhibited in the remains of the ancient Mexicans. The germs of that knowledge existed in Polynesia, and only required a suitable field for its development; for my friend Mr. Edward Hill informs me that the South Sea Islanders have, in certain islands, at least sufficient astronomical knowledge to steer their course by the stars.

* The substance of a journal during a residence at the Red River Colony; by John West, M.A., London, 1824.

Part III.

I now proceed to the third and last department of our inquiry, viz., to show that the same singular manners and customs, altogether unlike those of the rest of mankind, are observable alike among the wilder tribes, both of the Indo-Americans and the Polynesians.

Before mentioning any of these, I would remark upon the great resemblance in bodily form that has been observed by intelligent travellers, in comparing one of these tribes of mankind with the other. Speaking of the Indians of Acapulco in Mexico, on the Pacific coast, Captain Basil Hall, R.N., thus writes :—"Their features and colour partake somewhat of the Malay character; their foreheads are broad and square; their eyes small, and not deep-seated; their cheek-bones prominent, and their heads covered with black straight hair; their stature about the medium standard, their frame compact and well made."*

One of the most remarkable peculiarities in the manners and customs of nations is their different modes of disposing of the dead. On one of my voyages to England, in the year 1839, our good ship having sprung a leak a few days after leaving this port, we had to run for repairs to the Bay of Islands, in New Zealand, where we lay about ten days, shortly before the colonization of the New Zealand group had commenced. During my stay I visited the cemetery of the Bay of Islands tribe, situated close to the native village of Kororarika. There were no graves, however, to be seen in the cemetery; the dead bodies having each been wrapped up in mats, and laid upon trestles raised a few feet from the ground, and left to putrefy in the open air. During the following year, before my return to the Colony, I happened to visit the exhibition of American Indian curiosities of a Mr. Catlin, an American gentleman, of a very enthusiastic and adventurous character, who had been travelling for many years among the wild Indians of that country, and with whose family I had in the meantime become acquainted in New York; his wife, whom he had left behind him in the United States, having been entrusted to my care on her passage across the Atlantic to rejoin her husband in London. On one of my visits to Mr. Catlin's exhibition in the Egyptian Hall, London, I happened to see an interesting drawing, or rather painting, which he had made on the spot, of the native village of the Mandan tribe of Indians in Missouri, and I was greatly struck at observing that the cemetery of the village had precisely the same singular appearance as that of the New Zealand native cemetery I had seen a few months before at Kororarika, in the

* Captain Basil Hall's Voyage to South America, vol. ii., page 175.

Bay of Islands; the dead bodies in both cases having been wrapped up in mats and laid on trestles raised a few feet above ground. I afterwards found, however, that this was the usual mode of disposing of the dead among the wild Indians of America, so far north even as the Red River Colony in the Hudson's Bay Territory, as witness the following quotation from the journal of the Rev. Mr. West, already quoted above:—

"On the following morning I saw an Indian corpse staged, or put upon a few cross sticks, about 10 feet from the ground, at a short distance from the fort. The property of the dead, which may consist of a kettle, axe, and a few additional articles, is generally put into the case, or wrapped in the buffalo-skin with the body, under the idea that the deceased will want them, or that the spirit of these articles will accompany the departed spirit in travelling to another world."*

On the occasion of my visit to the cemetery at Kororarika I observed two other customs or practices of the South Sea Islanders, indicating, together with that of keeping the dead above ground, an Egyptian or contemporary origin, as ancient at least as that of the sojourn of the children of Israel in Egypt. There happened during my visit to be one of those periodical mournings for the dead in progress which are symptomatic of a similar origin. A number of native men and women were assembled in the cemetery—the former for the most part strongly tattooed, while the latter were ever and anon cutting themselves with mussel-shells till the blood streamed down from their cheeks as they gazed intently at the remains of the deceased; for one of the mummy-cases having in the meantime been taken down from the trestle and opened, the bones of the deceased—in all likelihood those of a superior chief, long deceased—were spread upon a mat on the ground; the ceremony being occasionally relieved with sudden bursts of dismal and unearthly wailings and howlings in honor of the dead. Now, it is worthy of remark, as a confirmation of my theory as to the extreme antiquity of the Polynesian and Indo-American races, that both of these savage practices—tattooing and cutting for the dead—which were doubtless common in ancient Egypt and among the earlier post-diluvian nations, were expressly forbidden in the laws of Moses to the children of Israel, as we find in the Book of Leviticus, chap. xix. 28: "Ye shall not make any cuttings in your flesh for the dead, nor PRINT ANY MARKS UPON YOU; I am the Lord." The practice of tattooing has all along been a national practice among the South Sea Islanders, although long disused in some of the islands; and the Rev. Mr. West informs us that it is still occasionally observed among the Indians of Hudson's Bay.

* "Journal of a Residence at the Red River Colony, British North America"; by John West, M.A.

There are various other practices or observances common to the Polynesians and Indo-Americans which I shall merely enumerate without dwelling upon them at any length. The necessity for *utu*, or satisfaction for any injury received, and the cherishing of feuds arising in this way for generations, is equally distinctive of the New Zealanders and the Indo-Americans, especially those of the northern continent. The manufacture of an intoxicating beverage from a root, called in the South Sea Islands cava, and in the equatorial regions of America cassava, evidently the same word, is equally common to both, as well as the very singular and disgusting mode of its manufacture; the root being chewed in some instances by boys, in others by young women, and in others again, as among the Cunas at the Isthmus of Darien, by old women; the residuum being collected in a large vessel and water poured over it, thereby inducing fermentation. The mode of catching fish also by throwing an intoxicating herb or root into the water; the separation of women, and prohibiting them from touching their food with their own hands for a certain time after childbirth, and the caste of blood being transmissible through the female and not through the male, are also equally common to both of these very ancient races of the family of man.

I have thus shown, I trust to the satisfaction of the Society, that the forefathers of the Polynesian race were separated from the rest of mankind, in the very infancy of the post-diluvial world, in the remotest ages in the history of man. I have also shown that at the period at which this separation took place, the world must have been in a comparatively advanced state of civilization, implying at least very considerable skill in the arts of life, and great ability in the use and management of the mechanical powers. I have shown, moreover, that the impression of this primitive civilization must have been photographed, so to speak, on the Polynesian mind, to be reproduced wherever they went, in every suitable field. I have likewise shown that after having crossed over almost the whole extent of the broadest part of the Pacific, the amphibious islanders reached at length the farthest east of the inhabited islands of that ocean, viz.:—Easter Island, in latitude 27·6 S., and that from that island, which is only about 2,000 miles from the west coast of America, a mere handful of unfortunates must have been caught suddenly in one of those violent westerly gales that are so frequent in the Southern Pacific, and been blown across the intervening tract of ocean to the American land—landing somewhere in the State of Chili near Copiapo, in the latitude of Easter Island. And I have expressed my own opinion very strongly that this arrival of a few famished Polynesians on the west coast of America must have taken place some time between twelve and fifteen hundred years before the birth of Christ; that is some time between the death

of the patriarch Jacob and the exodus of the children of Israel from the land of Egypt. A later date than this would scarcely suffice to account for the dispersion of the Indo-American nations over both continents, originating as they all did, agreeably to the testimony of Baron Humboldt, in one common source, as well as for the multitude of languages that have sprung in the course of long ages from that one source.

I maintain, further, that the original inhabitants of America, and their more immediate descendants, had brought along with them, from beyond the Pacific, a comparatively advanced form of civilization, which they reproduced in those colossal works of which the wonderful remains in Peru and Mexico have astonished the whole civilized world; but that this higher civilization had, from causes unknown to us, died out long before the era of the Spanish conquest. Dr. Von Martius, who maintains that the Indo-Americans are indigenous, created on the spot as an inferior edition of the genus man, and having no connection or relationship with any other portion of the human family, nevertheless admits the fact of this higher civilization having characterized the earlier ages of Indo-American history. "Colossal works of architecture," he tells us, "comparable in extent to the monuments of ancient Egypt (as those of Tiahuanaca on the Lake Titicaca, which the Peruvians, as far back as the time of the Spanish conquest, beheld with wonder as the remains of a much more ancient people), bear witness that their inhabitants had in remote ages developed a moral power and mental cultivation which have now entirely vanished. A mere semblance of them—an attempt to bring back a period which had long passed by—seems perceptible in the kingdom and institutions of the Incas."

It would appear, therefore, that long ages, perhaps, before the era of the Spanish conquest, a blight had fallen on the earlier and higher civilization of the Indo-Americans, and that it had, in a great measure, died out, as it would seem to have done completely all over the Pacific. But if we only take into considertion the remarkably peculiar circumstances in which the Indo-American nations were placed, as compared with the nations of the West, we shall not be surprised at this seemingly mysterious consummation. What other division of the human race would, in similar circumstances have attained a higher level than the Indo-Americans appear to have reached? Had Europe, for instance, been inhabited exclusively either by the Celtic or the Teutonic race for the last three thousand years—had that race been shut out from all communication with the rest of mankind—had they been equally ignorant of letters and of the use of iron—and had their only domestic animals been the dog, the turkey, the llama, and the duck, with no sheep or cattle or horses, or swine, and had their only species of grain been maize or Indian corn—I question

whether Europe itself would have vied at this moment with ancient Mexico or Peru. The nations of the West have in all past ages been jumbled together in the great political dice-boxes of Europe and Western Asia, each perpetually changing its relative position to the rest, and entering from absolute necessity into new combinations. Now, just as quartz pebbles lose their angles and acquire a sort of polish by being subjected to the rushing of waters in the bed of a rapid river, while they would doubtless have retained their original conformation and their less pleasing exterior if they had been lying all the while at the bottom of a lake—and as malt liquor, when it has become stale, revives and becomes brisk again when emptied from vessel to vessel—it appears to me that the changes of circumstances that have been experienced in all past ages by the Western nations, have been highly favourable to the general progress of civilization in the West, and to the general development of the mental energies of man. In short, when we consider the very unfavourable circumstances in which the Indo-American nations had been placed for countless ages, and contrast them with the stately ruins of their palatial and other noble buildings that indicate their past glory, the wonder is not that the Indo-Americans achieved so little, but that they achieved so much.

At all events, there is evidently a very wide field still open to the Australian literati of the future in tracing the developments of human society in such extraordinary circumstances as present themselves to the contemplative mind in the South Sea Islands, and among the Indo-American nations.

ON THE DEEP OCEANIC DEPRESSION OFF MORETON BAY.

BY REV. W. B. CLARKE, M.A., F.R.S., F.G.S., &c.

[*Read before the Royal Society*, 20 *July*, 1876.]

DURING the year 1875 I had the honor of laying before this Society, in my Anniversary Address, an account of the scientific researches carried on by Captain Nares, R.N., and the officers of the Scientific staff on board H.M.S. "Challenger," supplemented afterwards by "Notes" founded on reports of subsequent observations by Captain Thomson, R.N., who succeeded Captain Nares on the occasion of that officer's appointment to the command of the Expedition to the Arctic Ocean.

The topics treated of in my Address had reference principally to the Atlantic Ocean, with only scanty notices of the Pacific. The supplementary notes had more special allusion to the Pacific and the seas connected with it, and discussed Dr. Carpenter's deductions from some of the observations and experiments made by Captain Belknap on board the United States steamer "Tuscarora," in those parts of the Pacific with which we are more particularly interested.

Since that paper was read, in December, 1875, the "Tuscarora" arrived in Port Jackson, and I lost no time in visiting her then commander, Captain Miller, who had been commissioned by the United States Government to make researches, not on the extensive scale undertaken by the "Challenger," but chiefly for a safe submarine telegraph line to Fiji and New Zealand.

I was received very kindly by Captain Miller, and having learned the interest I took in such researches, he gave me satisfactory information and showed me the results as placed upon the chart. On requesting to be furnished with an Abstract of soundings from Fiji to Australia, it was courteously accorded by Captain Miller, who asked me to make no public announcement till after the middle of April, as he very properly wished his communication to be sent to the American Government.

In reserving my notice of the "Tuscarora's" work till the month of July I have not transgressed the limits to which her commander's permission extended. The particulars to be mentioned do not, however, include that portion of the intended line which would have connected Fiji with New Zealand, because, on its being known that a cable had been laid between that country

and this, that part of the "Tuscarora's" work was countermanded, and therefore no comparison can be instituted between the line now in operation and the one intended by the United States. After a brief stay in these waters, the "Tuscarora" sailed, as I understood, for San Francisco; but I believe she had not reached that port at the date of late advices.

I consider it only right to offer this explanation to the Society before I mention the contents of Captain Miller's communication, which is, though brief, of considerable importance, as pointing out some peculiarities in the ocean bed off the southern part of the coast of Queensland.

It is to be borne in mind that the instruments on board the "Tuscarora" were not of the elaborate character of those on board the "Challenger," some of which in operation I had the pleasure of witnessing in a dredging excursion off this coast; but they appeared to me to be amply sufficient for the purpose intended. Nor were there any means of obtaining the information so diligently sought for, as to the inhabitants of the deep ocean, by Professor Thomson and his able assistants. Nevertheless, Captain Miller had collected some interesting objects for future examination.

ABSTRACT of Soundings for Submarine Cable between Kandavu Island, Fiji Group, and Brisbane, Queensland, obtained by Commander Miller, in U.S. steamer "Tuscarora."

Date.	No. of Cast.	Lat.	Lon.	Depth in Fathoms.	Nature of bottom.	Remarks.
1876 Jan.		S.	E.			
25	76	19·11	177·41	1647	Yel-br. ooze	Position taken from bearings in British Admiralty Chart, No. 2,691.
	77	19·29	176·53	1915	Yel-br. ooze and coral.	
26	78	19·46	176·10	1728	No specimen	Stray line fouled cylinder.
	79	20·04	175·24	1763	Br. ooze and blk. sand.	
	80	20·21	174·42	1625	Br. ooze and sand.	
27	81	20·44	174·00	1460	Ditto.	
	82	21·03	173·22	1875	Coral.	
	83	21·20	172·35	1950	Br. ooze and sand.	
28	84	21·35	171·48	1372	Coral	Small specimen.
	85	21·48	170·56	1398	Br. ooze and sand.	
29	86	21·58	170·13	2165	Ditto	Small specimen.
	87	22·11	169·25	1627	White coral and sand.	
	88	22·36	168·52	747	Coral and lava ...	Off Walpole Island.
30	89	22·54	168·11	1009	White coral.	
	90	23·05	167·40	483	Coral and shells...	Isle of Pines in sight.
	91	23·16	167·09	460	Hard coral.........	No specimen. Cylinder came up flattened.
	92	23·22	166·41	1176	White coral.	
31	93	23·33	165·56	1938	Yel-br. ooze and white coral.	
	94	23·41	165·04	2055	Yellowish ooze.	
Feb. 1	95	23·48	164·19	1400	White coral.	
	96	23·88	163·26	1575	Coral and sand.	
	97	24·35	162·53	930	No specimen	Wire parted reeling in.
2	98	24·58	162·12	615	White coral and sand.	
	99	25·06	161·27	810	Ditto.	
3	100	25·11	160·41	993	White coral and sand.	
	101	25·18	159·52	715	Ditto	To Light-house, Cape Moreton, S. 73° W., 355 miles.*
	102	25·30	159·09	1383	White coral	S. 73° W., 320 miles.
6	103	26·12	156·04	2634	Brown mud	S. 68° W., 149 miles.
	104	26·31	155·07	2682	Ditto	S. 72° W., 95 miles.
9	105	26·03	154·23	2610	Ditto	S. 42° W., 76 miles.
	106	26·18	154·08	2485	Ditto	S. 42° W., 58 miles.
	107	26·32	153·51	562	Brown mud and sand.	S. 42° W., 36 miles.

* N.B.—The bearings to the light-house, Cape Moreton, were measured for me by Captain Hixson.

On reference to my last year's Address it will be seen that the "Challenger," when 30 miles from Kandavu, had a depth of 1,350 fathoms over red ooze. In the "Abstract" we find that the "Tuscarora" had yellow brown ooze, at a depth of 1,647 fathoms, in a position about 30 miles west from Kandavu. The observations from the two ships are therefore so far connected.

It is to be remarked, however, that in the "Tuscarora's" soundings between the Fiji Group and New Caledonia, coral and coral sand frequently occurred, and that the depths were very unequal, only one reaching below 2,000 fathoms, whilst on 3rd February, 1876, at a distance equivalent to 48 miles of latitude, the soundings between the Isle of Pines and Queensland deepened 668, from 715 to 1,383 fathoms, which would give a descending slope much steeper than that on our Western Railway line from its highest point to the sea. Moreover, the depression deepens again in a mean direction of N. 71 E. from Cape Moreton, in Queensland, and, in 225 miles of distance, to a depth of more than three vertical miles from the surface, and this within 95 miles from the Cape; rising again in less than 60 miles to less than three-quarters of a mile in depth in the same general direction.

This proves the existence of a very deep channel, not 100 miles wide, commencing about 36 miles from Cape Moreton. Connecting with the above calculation the "Challenger's" observations, we learn that it does not extend far to the northward, since the ridge from Sandy Cape to New Caledonia, &c., mentioned in my "Notes," cuts it off at about 1,300 fathoms, which is nearly the depth of the north-east slope at about 200 miles distance. This deep channel would therefore appear to have a direction towards that point of the compass. The absence of red clay and ooze from the "Tuscarora's" soundings is curious, but it is in agreement with the general depth assigned to deposits of that colour in the "Challenger's" observations, which occurred below 2,500 fathoms, and there are but three "Tuscarora" soundings between Kandavu and Brisbane exceeding that depth, against which we read "brown mud," "brown," and "yellow-brown," and "white," being the only colours noted outside the Queensland coast depression. It is, however, possible that colours may be variously estimated by different observers, as one of the "Tuscarora's" bottles contained what, to my eyes, appeared to have a reddish tint.

Soundings brought up by H.M.S. "Herald" off Fiji, many years ago, and supplied to me on board by Dr. Macdonald, F.R.S., were filled with *foraminifera*. The colour of the deposit now is a light grey, after long drying in my cabinet. As white coral was dredged by the "Tuscarora" only 320 miles N. 73 E. from Cape

Moreton, the reefs that stud the ocean around the New Caledonia Group extend much nearer to the Australian coast than many persons imagine, and betray the approach to the deep depression just mentioned, the north-eastern edge of which seems to be that of an uneven plateau or ridge in one spot, about 355 miles from Cape Moreton, only 253 fathoms lower than the ocean bed at a distance (on nearly the same bearing) of 36 miles from Cape Moreton. The bottom of the depression is thus about 91 miles wide, on each side of which there is an equal rise and fall of about 41 feet to the mile, and this is about the mean general steepness of the Blue Mountain Range in New South Wales along the railway line, from the summit to the waters of Port Jackson. These calculations are not, of course, given by Captain Miller; but I submit them merely to illustrate the probable slope of the coral reefs towards the west in the area referred to and the contour of the depression.

As the immediate coast of Queensland is comparatively low in the part indicated, this great depression appears contradictory to the usual idea of shoal water off a low coast; but I would explain it, as I do the condition of the sea bottom off the Illawarra coast, as showing a double escarpment with an intervening comparatively level plain or plateau from the mountain summit to the deepest sea bottom. One other inference is that our coast current streams along from the north-eastward over this deep depression and spreads its eddies under the impulse of winds. It would be very interesting to be able to state the depth of water in this current as well as the temperature below it from actual experiments. Judging from what has been determined respecting the Gulf Stream of the Atlantic, which is only 100 fathoms thick, that off our own coast is probably still more superficial. Nevertheless it must have a powerful influence in modifying the climate of the coast region, which is shown by the winter temperature of the water in Port Jackson.*

The depression in question is greater than that between our southern line of coast and New Zealand, as determined by the "Challenger."

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* During many years I have made comparative observations (but at irregular intervals, and in various localities, on the ocean in the line of the current) and have found the sea-water generally higher in temperature than the air. I prefer, however, to quote here from a "Comparative table of temperatures of sea-water and air" in Port Jackson, supplied at my request by my excellent and accomplished colleague, H. C. Russell, Esq., Astronomer, from whose data, giving the temperatures for every month in the last six years (1870-1875 inclusive) I collect that the mean for water is 65·1, for air 62·85; and that the maximum for water was 73·6, and for air 73·2; and the minimum for water was 56·1, and for air 51·2—all showing the influence of the ocean water.

The conformation of the part of the ocean-bed off Moreton Bay, as thus explained, is due to purely geological causes, of which the existence is illustrated by the escarpments and ravines yet extant on the land—the ooze and clay and coral sand brought up by the sounding apparatus and dredge being mere submarine superficial deposits, covering and partly filling the bottom of the depression. This analogy of conformation between the depths of the sea and the heights of the land is parallelled by the distribution of life (as has been shown by Dr. Hooker) on the ocean ridges and depths, only in reverse order to that on the land. "The ocean," he says, "thus mirrors one of the most striking features of the distribution of terrestrial life, and, mirror-like, it turns the picture upside down."

If we travel inland from Cape Moreton on the same general bearing exhibited before, we shall find an almost equal slope from the high lands at the heads of the drainages to Moreton Bay as appears on the slope of the Blue Mountains towards Port Jackson; for in 1853 I made the elevation of the granite domes near Maryland, by barometrical observations, 3,727 feet, and the dividing range between the Condamine and Dumaresq Rivers, at the head of the latter, 3,120—Mount Melbourne being 3,829, and Moubullon, or Craig's Range, 3,640 feet—Mount Cordeaux, according to Cunningham, being 4,100 feet, which is very near the height of the land above the tunnel on Mount Clarence, which itself is 3,658 feet. The relations of land and sea appear then to be nearly exactly equivalent to those in the southern coast region of New South Wales, since, though there are higher points in New England and in Maneroo, than those already mentioned, yet the general elevations are much the same in both districts, and as off Moreton Bay there is a deep depression, so there is another off Mount Dromedary and Twofold Bay. What relation these depressions have to each other is not yet fully ascertained; but it is nearly certain that the bases of New Holland and New Zealand meet somewhere about half way between them, and the stages of ascent are precipitous or with long inclined slopes, the deepest depressions lying as it were on each side of a submarine plateau.

In my view, the combined phenomena as exhibited by the opposite coasts of these countries (which formerly extended further into the ocean)—by coral reefs and other conditions—induce the conclusion that great rents and denudation in the earliest periods of our geological history were the result of depression and submergence, affording channels for ocean currents, deep receptacles for cold stagnant water, and passages for such surface currents as that which bathes New South Wales with a stream warmed in latitudes nearer the Equator than that of Sydney or Brisbane. Much of the history of that stream has to be discovered, but the fact elicited respecting the submarine valley north-easterly from

Cape Moreton is an item in the account. I have thought it, therefore, worthy of especial notice.

If, for the sake of illustration, we could raise New Holland, New Zealand, New Caledonia, and New Guinea, to one uniform additional height of some 2,600 fathoms above the ocean, we would, I think, perceive similar features on the surface, so formed, to those which are now exposed, and be able to show what can now be only surmised, that the remark of Dr. Hooker before referred to is strictly true; and also, that in examining critically the present surface of the land, we can reproduce what the ancient surface was which is now buried beneath the waters. And from the examination of such portions of the ocean-bed as have been sounded, we may gain valuable hints in the endeavour to account for many of the superficial phenomena of the still exposed and denuded dry land.

In corroboration of this view of the subject, I will conclude with a quotation from a very important work of Mr. Alfred Russell Wallace, just published, "*On the Geographical Distribution of Animals, with a study of the relations of living and extinct Faunas, as elucidating the vast changes of the earth's surface.*"

"The well-known fact" (says that accomplished writer, vol. i, p. 35) "that nearly three-fourths of the surface of the earth is occupied by water, and but little more than one-fourth by land, is important as indicating the vast extent of the ocean by which many of the continents and islands are separated from each other. But there is another fact which greatly increases its importance, namely, that the mean height of the land is very small compared with the mean depth of the sea. It has been estimated by Humboldt that the mean height of all the land surface does not exceed a thousand feet, owing to the comparative narrowness of mountain ranges, and the great extent of alluvial plains and valleys; the ocean-bed on the contrary, is not only deeper than the tops of the highest mountains which rise above its surface, but these profound depths are broad sunken plains, while the shallows correspond to the mountain ranges, so that its mean depth is, as nearly as can be estimated, 12,000 feet."*

It being no part of the present subject to go further into the former connection of Australia with New Zealand, the remarks of Mr. Wallace, founded on the relationship established between certain portions of the Faunæ of those countries, as evidenced by those of the intermediate islands, have not been alluded to on this occasion, but he offers sound reasons for the belief formerly

* "This estimate has been made for me by Mr. Stanford, from the materials used in delineating the contours of the ocean bed on our general map. It embodies the results of all the soundings of the "*Challenger*," "*Tuscarora*," and other vessels, obtainable up to August, 1875." [The *Abstract* above given is, therefore, additional to those mentioned by Mr. Wallace.]

expressed by me that such a former connection is highly probable, notwithstanding the enormous depression now existing between New Zealand and Australia.

Mr. Wallace shows that even now the land on the face of the globe "is nearly continuous, and that it is possible to go from Cape Horn to Singapore and the Cape of Good Hope without ever being out of sight of land, and, owing to the intervention of the numerous islands of the Malay Archipelago, the journey might be continued under the same conditions as far as Melbourne and Hobart Town." (p. 37.)

SOME NOTES ON JUPITER DURING HIS OPPOSITION OF 1876.

By G. D. Hirst.

[*Read before the Royal Society of N.S.W.*, 2 *August*, 1876.]

I suppose that of all the members of our solar system, with the exception perhaps of our satellite, the Moon, there is no object that so soon engages the interest or more readily yields to the scrutiny of the amateur astronomer, when, with his newly-acquired telescope before him, he sets himself to investigate some of the wonders of the heavens of which he has been hitherto altogether heedless, or which at best have excited his idle curiosity as they have met his gaze, than the giant of our planet-neighbours, Jupiter; and the reason of this a slight inquiry will, I think, make obvious.

Mercury, as far as we at present know the closest of our Sun's attendants, is an almost hopeless object for even the possessor of the finest telescope. His minute size, and in consequence of his position his intense luminosity, prevent anything like details ever being seen. Moreover, when in his most favourable position for observation, which is when he is furthest from the Sun, we, from his orbit being interior to the Earth's, see but half his disk illuminated. Therefore, to these unfavourable circumstances we must attribute the title Mr. Webb has given him in his "Celestial Objects" of a neglected subject.

To Venus much the same arguments apply. Being larger than Mercury, and also nearer to the Earth, we certainly do see somewhat more of her; but her brilliance baffles all satisfactory definition, and I think no well-accredited markings or details of any sort have ever yet been accorded of this, to the eye most beautiful, but in the telescope most disappointing, planet.

Passing now to Mars, the first exterior planet to the Earth, we see what neither of the interior two can ever show us—a full round disk illuminated by the solar light; and we have the further advantage of our object being brought at favourable oppositions very near the Earth. Here we can see marks which no very great stretch of imagination or analogy may lead us to suppose as representing land and water, more especially as adequate optical means enable us to descry white spots at his

poles, which, by their diminishing during the Martial summer and increasing in his winter, convince us to be ice. Still, with the possessors of small telescopes, Mars is not I think a prime favourite. The period during which we can advantageously observe him is short—a few weeks before and after opposition; after which he rapidly recedes from us, and his orbit carries him so far off that his disk dwindles down to most uninteresting proportions, and his markings are lost to all small glasses. Besides, even at opposition it requires a really good and powerful telescope to do satisfactory work on Mars. In the best drawings that I have seen there is a strange haziness about details, and different observers appear to me to disagree most woefully in their delineations.

Saturn has for many I must confess, including myself, a large number of attractions. I cannot well dwell at present on the subject, as it is foreign to the object of this paper; and even a short account of his wondrous details would require a paper by itself. Still, confining myself to the premise that I am speaking almost exclusively of amateurs, and as such possessing only moderately powerful telescopes, Saturn, from his enormous distance, presents difficulties which Jupiter does not; his ring, with Ball's division, perhaps a belt, and three or four of his satellites, are as much as most small telescopes show; what has been discovered besides are details of great delicacy, and some points connected with Saturn remain tests for the largest and most perfect telescopes of the present day.

So there remain but Uranus and Neptune; and I wonder, out of all that have ever lived on the earth, how many have ever seen these at all. Indeed, a very few. They might, I fancy, be counted on your fingers; and, should an ordinary observer get one of these outside wanderers by accident into the field of his glass, he would probably pass them by as fixed stars.

We return therefore to the subject which brings me before you—Jupiter. How readily his noble disk shows out in even the smallest glass, many of you—and I suppose that there are few here who at some time or other have not seen him through a telescope—are well aware. An aperture of even a couple of inches will show some signs of streaks on his disk, and his moons quite brilliantly. As we increase our aperture and power, more and more detail comes into view, the belts assume definite form, traces of colour are seen, and his four satellites turn out very respectable-sized disks of their own. Their shadows, their occultations, and their eclipses present a scene of ever-varying interest and beauty; and this, with the extreme facility with which it can be seen in even what are now considered small telescopes, makes Jupiter, as I said before, a most interesting object for all amateur observers.

About the beginning of May the following circular from the Royal Astronomical Society, London, was handed to me:—

"Royal Astronomical Society,
Burlington House, London, W.,
March, 1876.

"The periodicity of changes in the colour and markings upon the planet Jupiter, and the connection that has been suggested between them and the solar phenomena, render it most desirable that a general system of observation of the planet should be organized. To this end, Dr. Lohse, in the year 1873, appealed to astronomers in the Northern hemisphere, and a response was made which has enabled him to collect and put on record many valuable descriptions and drawings of the planet's appearance since that time.

"The Royal Astronomical Society of London is deeply impressed with the importance of the question; and to assist in carrying out the plan of international observation suggested by Dr. Lohse, it has appointed us as a committee to endeavour to enlist the sympathies of observers generally, so as to obtain as extensive a series of observations as possible.

"The Southern declination of the planet will for a few years prevent satisfactory results being obtained in Europe, and we therefore desire to appeal to Southern observers to continue the work already begun.

"Drawings of the planet's appearance should be made as frequently as possible, giving in all cases the local or Greenwich meantime of the sketch, with particulars of the instrument and power employed, and the state of atmospheric definition.

"Careful notes of the tints and colours of the belts are most important.

"Particular attention is requested to the occurrence of the small bright spots, first observed by Mr. Lassell, and to the approximate Jovicentric latitudes in which these spots appear; also to small black spots which are occasionally seen in the equatorial zone.

"The phenomena presented by the satellites in transit, and their varying brightness considered with respect to their orbital position, are matters on which accurate observations are much desired.

"To ensure uniformity, we beg to send you some forms on which drawings can be made. These have a polar flattening of one-sixteenth. In all cases the north and south poles of the planet should be indicated in the drawing.

"All drawings and communications should be sent to 'The Secretary of the Jupiter Committee,' Royal Astronomical Society, Burlington House, London, W.

"Your obedient servants,
WILLIAM HUGGINS.
E. B. KNOBEL.
LINDSAY.
OSW. LOHSE.
A. C. RANYARD.
ROSSE.
F. TERBY.
T. W. WEBB."

Having at the time the use of a fine 10¼-inch silvered glass reflector, the property of Mr. J. U. C. Colyer, who has for these and other observations kindly placed it at my disposal, I determined immediately on receipt of this circular, to commence and carry out, as far as lay in my power, a systematic course of observations, accompanying them by sketches made at the telescope, and the results up to the present are now before you. In making these

drawings I have been aided by a most efficient driving-clock, which keeping the object in the centre of the field of the telescope leaves both the hands free for other work, the advantage of which can only be appreciated by those who, in their attempts to delineate the heavenly bodies, are obliged to have one hand constantly employed in screwing away at a handle, to follow the motion of the object as it rapidly flits through the field.

The construction also of the Newtonian reflector is peculiarly adapted for drawing purposes, as the erect position of the observer is easy and natural; and with your desk at your elbow, you can rapidly transfer your eyes from the telescope to the paper before you.

On the whole I must say that the weather we have been favoured with since I commenced these observations has not been eminently adapted to telescope-work. We have had a rather more than fair allowance of cloudy evenings, and many of the most brilliant nights have been utterly worthless, from their blurred and tremulous definition; moreover, there appears to be at all times present a considerable amount of vapour in the higher regions of the atmosphere, so that even when definition is most steady, you have a consciousness that you are looking at the object under a veil, the field of the telescope not appearing perfectly dark as it should do. This is more especially tantalizing, as even on some of the most inferior nights you get moments—they only last for a second—of most startling definition, when the planet seems to be brought to within half its usual distance, and details start out before you so numerous, and so complex, that the eye in that evanescent moment totally fails to grasp them, and the next second they are gone, and you are left with a dazed impression that you have seen *something* that would tax the skill of a far more accomplished artist than yourself to do the slightest justice to. I have at times—but only, as I said before, for a second—seen the whole of the disk of Jupiter covered with fine lines; even the white belts, which ordinarily present not a trace of marking, are scored by them all over; and the darker equatorial zone appears a mass of flocculent, cloudy matter; but to attempt to put this on paper during the fleeting moment it is visible is an impossibility.

While on this part of my subject I may mention that one of the first things that attracted my attention, when looking up the observations recorded of Jupiter during the last ten or fifteen years, was the remarkable paucity, I might almost say the entire absence, of any reliable or well-executed drawing of the planet. I must, of course, confine this assertion to any published drawings for there may be, and probably are, many fine delineations in the hands of those who drew them, which will never see the light; but speaking of those pictures which have been given to

the scientific world through the medium of the papers of astronomical societies, periodicals, or books, I must confess it a matter of great surprise, that so few and such crude attempts have yet been made to give to the general astronomical reading public an idea of the telescopic appearance of this, the most magnificent of our planets; and the reason I am at a loss to see; for as I have before said, Jupiter is certainly, excepting our Moon, the easiest of all telescopic objects, and after a little practice, any one I am sure, with a decent notion of using his pencil or chalks, may give a far more accurate representation of the planet than he will find in the most elaborate and expensive astronomical work he can lay his hands on. Very few drawings ever represent colours at all; in a very extensively got up work I have in my library the belts are represented as straight lines—as if, to save trouble, they had been drawn with a ruler; in others there is an attempt at a ragged, cloudy appearance, but the artists who represented them evidently drew from what they had heard rather than from what they had seen. Messrs. De La Rue and Lassell have both furnished what have been said to be remarkably fine drawings, and probably the originals may be; but if this is the case a lithograph copy of one of them that I have seen must be a most woeful libel. Mr. Browning, of London, has one or two coloured representations of Jupiter; his most recent, I think, is that in the fifth volume of the "Student and Intellectual Observer." The volume is now before you, and I should be glad if any member present would tell me if it represents anything like what he has ever seen of the planet. In making these remarks, be it understood, I am not claiming for my own attempts any superiority; nobody can be more conscious than I am myself of their shortcomings, and much that I have seen has baffled all my endeavours to pourtray—as for instance, I have again and again, on favourable opportunities, seen a perfectly metallic appearance on some parts of the equatorial zone, which I cannot even describe, much less draw; so what I have said is not so much to depreciate what has already been done, but to express a surprise that more has not been done in this class of astronomical work, by those who have the skill, the time, and the instrumental means.

You will notice that the circular of the Royal Astronomical Society expresses that a connection has been supposed to exist between some of the phenomena observed on Jupiter and the maximum and minimum of the solar spots. From the evidence as yet adduced it cannot be said at present to amount to more than a supposition; still, as Mr. Russell very pertinently observed on the first meeting of our Astronomical Section, speaking on this subject—" We may not but believe that any disturbance affecting our ruler (the Sun), must pulsate through the whole retinue of

his dependents, bound together inseparably as they are by the law of gravitation."

Whether these influences, as in the case of Jupiter, make themselves manifest to us by what our telescopes show us to be going on on his disk cannot yet however be placed among astronomical facts. It is to obtain evidence on this point that they are so anxious in the Northern hemisphere that Southern observers should fill the gap which, in consequence of the great Southern declination of Jupiter, would otherwise exist in the records on which this theory is to be built.

Turning our attention now to the minute white spots mentioned in the circular, let us see what records we can find of their previous appearance, and what connection we can trace between their apparition and the maximum of the solar spots. I think we shall find there are some striking coincidences.

The first account that I can lay my hand on is one by Cassini, in the "Mémoires de l'Académie" for 1692, where there is a paper in which he notices great changes and bright spots on Jupiter. I find there was a sun-spot maximum for the year 1693.

There are some observations of Sir William Herschel of white spots and irregular bands in 1778, 1779, and 1780. He also observes what he calls a similar appearance in 1790. Two very considerable solar and magnetic maxima occurred—the one in 1779, and the other in 1789.

In the year 1848 the Rev. W. R. Dawes perceived some very remarkable white spots in Jupiter, which he likened to the circular craters on the Moon, and on the 27th March of the following year, Mr. Lassell saw them in his 20-feet equatorial reflector. Again, in May of the same year, Professor Schumacker, of Altona, observed four or five of these features on one of the belts, which he thus describes:—"They are white spots, and are all perfectly round, distinct, and bright. The largest of them is as distinct and well-defined as the disk of a satellite appears in a 9-feet reflector. They are striking phenomena, keeping their relative positions, as they are carried along by Jupiter's rotation, and there are no other similar spots on his disk." A sun-spot maximum occurred just at this time. De La Rue, in 1856, very near a sun-spot minimum, with 13 inches of aperture, makes a drawing showing no traces of white spots, and another drawing made at the same time by Piazzi Smyth, on Tenneriffe, agrees almost entirely with his. Lassell again, in 1859, approaching a spot maximum, figures the white markings, and says he "had failed to see these spots for many years, but latterly they had appeared again." In 1861, Sir W. Keith Murray contributed some drawings with a 9-inch refractor showing the spots, and other observers confirmed his observations with telescopes of 5 inches and upwards. At the same time the report of the

Greenwich Observatory states that, with the great equatorial, Jupiter presented appearances not previously recorded, and drawings made from that telescope by Mr. Carpenter coincided entirely with Sir W. Keith Murray's. The next maximum of 1871 I find comparatively bare of records; but there are accounts scattered here and there among the notices of the Royal Astronomical Society, of bright spots and patches observed on the equatorial belt; and if my own negative evidence goes for anything, I may state that during this year, which is just after a spot minimum, though I have attentively watched for these phenomena, I cannot record a single sign of them.

Testimony so far appears to point to a strong probability of the connection of these remarkable features with our eleven-year solar disturbances; but more is needed before we accept the theory as a fact. If the Earth were viewed from a distance, the auroras most prevalent about the maximum period might give a perceptible tint to parts, but they would be near the poles; there might be similar phenomena producing similar changes on Jupiter.

The small black spots mentioned in the circular appear to be a class of objects of somewhat more recent observation, and, so far as we can judge from the few observations recorded of them, they seem to coincide with the solar minimum of spots, as the bright spots do with the maximum. They are somewhat minute objects, and might be easily overlooked unless the observer possessed a good glass of large aperture, and an eye used to this particular work; but granting these conditions—and they become on favourable nights very conspicuous and remarkable phenomena—I have at times seen these spots so intensely black that I could scarcely persuade myself that they were not the shadows of satellites crossing the disk of the planet; but that this is not the truth becomes apparent if we watch them, for they retain their relative position with the other markings, and rotate with them, which of course the shadows of satellites do not do. It is difficult not to believe that these spots have a different nature from the well-known shadings and belts: they are so hard in their outline, and so very much blacker than any of the other markings. It has been I believe suggested that they may be the tops of mountains protruding through the cloudy envelope surrounding Jupiter; but, if this is the case, they must possess extraordinarily feeble powers of reflection, to appear so dark by contrast with their surroundings.

I have prepared a diagram on a large scale of the disk of Jupiter, which I hope my astronomical friends present will not laugh at. It is not intended to present the appearance represented by Jupiter at any one time, but rather as a map combining some of the more remarkable and persistent features I have

observed on his disk. I hope by its aid to make some of my remarks more intelligible, and have purposely exaggerated both colours and markings, in order that they may at a distance make themselves more readily seen. The black spots, you will observe, make their appearance principally on the darker bands; in fact, I have only recorded one occasion on which I noticed a black spot on the brighter portion of the planet, but that was a very remarkable one; it was quite as black as the shadow of No. 1 satellite, and was connected with the equatorial belt by a thin ligament. The next thing I would direct your attention to is the colour of the various portions of the disk; and here we open Pandora's box of trouble; for different eyes, different telescopes, and different states of our atmosphere, combine to give most conflicting statements. There is matter enough in this portion of my subject to form a treatise by itself, but time will not permit me to do more than give a brief statement of facts, and leave theorizing on the matter for some other occasion. I would, however, first give you a short account of what I have been able to find recorded of previous observations of the colours of Jupiter, in order that you may compare them with my own, as illustrated in the drawings before you.

Sir William Herschel, in "The Philosophical Transactions, 1794," says—"I viewed Jupiter with a 40-feet reflector. There are two very dark, broad belts, divided by an equatorial zone or space, the colour of which is of a yellow cast." To take more recent observations, I note that on 7th November, 1869, Mr. T. Elger, of Bedford, says—"I noticed the space between the central belts was peculiarly ruddy." Mr. Salter, of Manchester, says, on the same date—"The colour of the equatorial streak was rich tawny." Mr. Gledhill, F.R.S., same date, says—"Whenever the air was good the ruddy tinge of the equatorial belt was easily seen." A photograph of the planet taken in this year shows the equatorial belt absolutely transparent, the light from the ruddy belt having failed to act upon the sensitive plate; yet, speaking of this particular photograph, Mr. Browning says, he has seen photographs taken at other times when this belt exerted the most action. In the year 1871 Mr. John Browning devoted some attention to the planet, and his drawings show the equatorial belt to be of a bright yellow colour. Towards the end of 1871 there appears from various records to have been a general diminution in the intensity of the colours, and more especially in that of the equatorial belt, which had lost much of its yellowish hue. In 1872 Mr. Birmingham describes the equatorial belt as rose-coloured. In the same year Mr. Browning again draws the planet, and his views show a reddish yellow. The colour generally of the planet in this year, from various records, seems to have been particularly vivid, and Mr. Lassell appears especially struck with it. I will quote his

remarks, for perhaps some may think I may in my drawings have been inclined somewhat to exaggerate the colours—a fault I have most carefully tried to avoid. On the 2nd June, 1872, he says, using a 24-inch reflector—"I acknowledge that I have been hitherto inclined to think that there might be some exaggeration in the coloured views of the planet; but this property of the disk on the occasion I speak of was so unmistakable that my scepticism is at last beginning to yield. I have attempted in the accompanying drawing to represent the colours as faithfully as I can, and to convey something like a general notion of the distribution and intensity of the various lights and shades scattered over the planet, but to give anything like a faithful outline of the individual phenomena is far more than I can pretend to." These words of Lassell have come home forcibly to myself, again and again, when in moments of magnificent definition, such a wealth of detail has been presented to my sight that my pencil has lain idly by, and I have been content to gaze in almost open-mouthed wonder.

After 1872 the planet appears to have for some time shown no remarkable amount of colour—at least I have not been able to put my hand upon any observation in which the equatorial belt has been especially noticed as presenting anything particularly unusual in this respect. And Mr. Browning says, in June, 1873—"The colour of the equatorial belt of Jupiter was fading during the last weeks of the previous opposition; during the present opposition the colour has been scarcely, if at all, perceptible." In the same year Dr. Lohse, as you will have noticed in the circular, made an appeal to astronomers generally in the Northern hemisphere, that drawings should be systematically taken of the planet. One of the results of this request, and the only one that I am able to show you, was a series of drawings made by Dr. Copeland, using the great Lord Rosse telescope of 6-feet aperture. A lithographic reproduction of these is now on the table. I believe these drawings were thought a great deal of at the time, and they were specially mentioned at a meeting of the Royal Astronomical Society, as showing an immense amount of detail; but I may mention that I have repeatedly observed more detail in the 10½-inch reflector on an ordinary night than is shown in any one of them. You will observe moreover, that there is a reddish tinge in all of them, pervading the whole of the disk. This I cannot fancy really belongs to the planet, but is communicated by the metallic reflector; for it is a known fact that these old metallic reflectors gave all objects a ruddy hue, and it is believed that this explains the appearance of so many red stars in the elder Herschel's catalogue.

The most noticeable feature in these drawings of Lord Rosse is the great loss of colour sustained by the equatorial belt. This

belt, which in 1870 was so red that, according to a naked eye observation of Dr. Copeland in September of that year, the general colour of the planet's light was affected by it, shows in nearly all these illustrations very little (if any) colour at all.

In the year 1874 there appears to have been an increase of colour, for Mr. E. B. Knobel says—"The colours of Jupiter this year have been far more conspicuous than in 1873. A marked change in the tint of the equatorial zone has taken place. In May 1873 it was observed of a decided brick-red tint. On no occasion this year has that tint been remarked, but a bronze yellow or sienna has prevailed for the whole period of observation, though perhaps on one or two nights it approached more to a rich yellow."

After remaining at a minimum of colour for two or three years, Jupiter seems now to be regaining his tints; but in many cases I have noticed a marked difference between what I now observe and what has been previously recorded. On first directing the telescope to this planet, at the beginning of May last, I was immediately struck with the bright orange-yellow of the equatorial zone. This was most conspicuous with all powers from 50 to 500, and could still be traced with the aperture reduced to 4 inches—the colour was of course much affected by bad definition—when the air was unsteady it required almost the full aperture to show its existence, and the reduction then required to give a clear perception of the dark streaks would render it almost invisible; but on a steady night, when a magnifying power of (say) 200 could be used with the full aperture, the equatorial zone has appeared almost invariably, with one or two exceptions which I shall mention by-and-by, of a rich orange. Shortly after I commenced the present series of drawings, I had occasion to show some of them to Mr. H. C. Russell, of the Observatory, who was himself engaged in similar observations. The first thing he said when he saw them was—"Why, you don't use the same colours that I do at all." A short time subsequently I went to the Observatory for the sake of comparing the telescopes, and to my utter surprise the equatorial belt that I had invariably observed with the reflector to be a tawny orange or yellow appeared in the 11½-inch refractor of a bright rose-pink. That this was no sudden change in the planet has since been amply confirmed, for Mr. Russell's drawings and my own on the same nights show each the different colour. Moreover, I have on other occasions compared the glasses, and the same distinction still exists: the reflector continues to show the equatorial belt yellow, and the refractor pink. The same pinkish tint has been observed by me, though in a less degree, on account of the smaller aperture, in a fine 4¼-inch refractor, the property of Mr. Alfred Fairfax, of Double Bay. Mr. Russell has recently erected an 11-inch silvered glass reflector of his own manufacture at the Observatory, and he confirms my

opinion as to the tawny yellow of the equatorial zone, as seen in that description of telescope.

Now I must confess I am at present totally at a loss for a theory to account for these contradictions. The refractor showing, as the best object-glasses do, a fringe of uncorrected purple or violet light round a bright object such as Jupiter, ought according to theory, to give the planet if anything a yellow tint, that being the complementary colour; but this is exactly what it does not do. The refractor, on the contrary, ought to give a reddish cast, as the reflection from silver is slightly tinged with that hue; but this is just the colour that *it* refuses to show. There is some unexplained mystery here, which I cannot now stay to inquire into, but content myself with putting just the bare facts before you.

The great equatorial belt of Jupiter appears at times to be the seat of sudden and violent disturbances, taking place on a scale of which we can scarcely form any conception. I have seen the whole appearance of this belt alter during the interval of from one night to another, so that though the same portion of the disk was presented to the eye, not a single feature in this part of the planet could be recognized in the drawing of the previous night. One notable example of this occurred on the 24th May. The equatorial belt had presented a particularly quiescent appearance for some time before, occupying not more than a third or a fourth of Jupiter's diameter. On the evening of the 24th of that month I noticed that it had suddenly spread over fully one-half of the disk, and seemed to be the seat of the wildest commotion, being torn and twisted in the strangest manner. Curious to say, this only applied to one side of the planet, for the opposite side preserved the calm appearance before referred to, the equatorial zone being exceedingly narrow. This outbreak lasted for some two weeks, and then gradually appeared to calm down. On the 23rd June there was another similar outbreak, accompanied as before by another extension of the equatorial belt, and also—and this is why I particularly mention it in this part of my notes—by an almost total loss of the yellow colour so remarkably predominant before in this part of the planet. This loss of colour seems to arise from the spreading over the yellow belt of the dark-gray or chocolate-coloured bands with which it is usually streaked; during these out-breaks they appear to extend as it were laterally, and to colour almost completely the yellow, which is only then seen between them in thin streaks. A strange feature noticed by me on the 4th July was that one of these dusky bands was bordered by a narrow edge of crimson lake; it could not have been more than a second or two of arc in diameter, but was most vivid; and it gave me almost the impression as if I were looking at a scarlet or crimson flame.

The polar portions of Jupiter, to which I will next direct your

attention, do not present the same ever-varying character of the equatorial belt; the causes which produce such tremendous disturbances at the equator do not appear to affect in anything like the same degree the northern and southern latitudes. You will observe in the large diagram, that I have coloured the north pole a decidedly brownish green, and this is the almost uniform tint that it has presented to me. On evenings of bad definition the green is scarcely visible; but when the air is sufficiently steady it is most conspicuous, and is a very beautiful feature: it requires a certain amount of magnifying power and considerable aperture to bring it out well; it is scarcely apparent with anything under 100, and a power of not less than 200 is by far the best, if the air will bear it. The reflector seems to possess a decided advantage over the refractor in showing the green tint; in the large Observatory achromatic it appears to me more of a smoky brown. The only record I can find of a green tint being observed at the poles is one in the "Transactions of the Royal Astronomical Society," by Miss Hirst, a lady residing in Auckland, who observed Jupiter during his opposition in 1875 with an 8½-inch reflector. She says—"On February 20th I noticed a small oval patch of a decided sea-green at the south pole, which on the following morning was more elongated and a shade darker in the centre. It remained thus for three days, and has not since been seen." The south pole has on all occasions been tinted with a warm gray. The most remarkable feature on this portion of the planet has been the persistent appearance of a cloudy mottling, which I have attempted to represent in the diagram. This was first noticed on the 3rd May, and it has continued to appear at intervals up to the present date.

Of the markings generally on the planet there are one or two which I will mention as being particularly characteristic and persistent. The strangest-looking of them is the one Mr. Russell and myself called the "Fish," on account of its presenting something of that form. It first made its appearance during the great outbreak about the 24th May; and it existed, though somewhat altered in shape, until the 4th July; there were always one or two black spots on the southern edge of it. The next peculiar marking was one I called the "Tuning-fork." I have represented it here on the diagram. On the north rim of the equatorial belt there appeared from the beginning of May to the middle of June a succession of remarkable breaks, the dark band on the following side being as it were cut short off, and on the preceding side it is thrown suddenly up, and extends right across the disk in a thin streak.

We have been accustomed to talk of the belts and clouds of Jupiter as if they were in their nature somewhat analogous to the clouds of watery vapour in our own atmosphere, or as perhaps

exhalations from molten matter constituting the body of the planet. But there is sometimes a strange persistency in these features, which seems incompatible with a vaporous nature only; and I think that those who have had the best opportunities for observation in this particular subject will be the last to hazard an opinion as to their origin. Unfortunately, too, the spectroscope fails to help us here: for Jupiter, shining as he does by reflected light, gives back the solar spectrum, with the addition of a few lines somewhat similar to those added when the sun is low down, and, consequently, shining through a considerable extent of our atmosphere. The spectrum, too, of Jupiter is, contrary to what many would suppose, exceedingly faint, being only about equal to that of a third magnitude star; the brilliant aspect that he presents to the eye being occasioned by the immense size of his disk, and not by its intrinsic luminosity. When I say that Jupiter shines only by reflected light I am aware that amongst some eminent authorities it is believed that he does emit somewhat more light than he receives; and Proctor, writing on this subject, says—"If Jupiter does not shine somewhat by native light, his surface must possess reflective powers nearly equal to white paper, which is scarcely credible." But this excess of brilliance, if it does exist, is too small to make any difference in the spectrum.

I feel the limits that I can fairly allow myself for occupying your attention will not permit of my entering into half of the many features which this interesting planet has presented during the present opposition, and of which I am persuaded much is new, and has in consequence never been recorded before. I will not, therefore, dwell now on the phenomena connected with the satellites, their transits, their shadows, and many other details of which more than enough remain for another discussion. Still less would I detain you by any attempt of my own to theorize on these wonderful and complex operations taking place on such a mighty scale—a scale of which the inhabitants of our little globe, 8,000 miles in diameter, can form no adequate idea. What, for instance, should we think if we saw, supposing that we could see, a black mass of vapour, or it may be of some far more solid substance, 22,000 miles in extent, suddenly break up and disappear in the course of a few minutes; and yet this very phenomenon was recorded by Sir James South to have taken place on one occasion when he was observing Jupiter.

There is, however, one theory of Proctor's in reference to the condition of Jupiter as affecting his colour which I will mention, as it seems to me to be one of the most reasonable yet broached, and moreover appears to accord well with observation. He thinks at a first view that nothing could appear more surprising than a change affecting the colour of a zone-shaped region whose surface is many times greater than the surface of our earth.

A brief change might be readily explained as due to such causes as affect our own air. Large regions of the Earth are at one time cloud-covered, and at another time free from clouds; such regions seen from Venus or Mercury would at one time appear white, and at another would show whatever colour the actual surface of the ground might possess when viewed as a whole. But it seems altogether impossible to explain in this way a change or series of changes occupying many years, as in the case of the colour changes of Jupiter's belt. It is one of the strongest arguments against the theory that solar action has to do with these changes, that any changes produced by solar influence would be so slight as to be in effect scarcely perceptible. If, however, Jupiter's whole mass be in a state of intense heat, we can understand any changes, however amazing; we can see that enormous quantities of vapour must be continually generated in the lower regions, to be condensed in the upper; and although we may not be able to indicate the precise reason why at one time the mid-zone or any other belt on Jupiter's surface should exhibit the whiteness which would seem to indicate the presence of clouds, and at another should show a colouring which appears to indicate that the glowing mass below is partly disclosed, we remember that the difficulty corresponds in character to that which is presented by the phenomena of solar spots. The most probable hypothesis appears to be that the ruddy glow of Jupiter's equatorial belt is due to the inherent light of glowing matter underneath his deep and cloud-ladenatmosphere.

This seems, as I said before, to be about the best theory yet advanced in this matter; but the human mind craves for something more substantial than mere supposition. And the questions that naturally arise when concluding a series of observations like the present are—Shall we ever in our present state *know* any more of the real nature and purpose of these magnificent orbs; shall this opposition of 1876 ever furnish a link in the chain that is to lift the veil that hangs on all outside; or are we but accumulating a pile of facts, a mass of observations, which, like the scattered necklace-beads, want the connecting string to form them into one harmonious whole? Are we, like the benighted wanderer in the desert, travelling in a circle, to find ourselves back at the point whence we started? Is it ever with the telescope and spectroscope to be "thus far and no farther"?

No! I cannot but believe that the time will come, though it be generations hence, when the fruit of many years of patient watching shall be,—the reversal of the complex pattern on the under side of which we have so long toiled, tracing with anxious care its numberless perplexing threads, and then the design of the Creator in the solar system will stand revealed in all its symmetry and beauty.

DISCUSSION.

Mr. H. C. Russell said, that Mr. Hirst had done a valuable work in watching so closely the changes which had taken place in the planet Jupiter during the present winter. A great many curious things had appeared.

Mr. Hirst had tried to collect the observations made upon the white spots, and to show that they had some connexion with the periods of the maximum sun-spots. If such a connexion could be shown satisfactorily, it would have much interest; but in 1863 he (Mr. Russell) saw the white spots on Jupiter most distinctly. He had never seen them so well since, and 1860 was the maximum sun-spot period before 1870.

The black spots were similar in form to the white spots. A theory had been hazarded that perhaps they were cyclones opening up the cloud envelope which is supposed to reflect the sun's light to us. If so, the persistence they maintain in their relative distances is very curious. He (Mr. Russell) had not been able to detect any difference in their position for a considerable time. Jupiter is 1,300 or 1,400 times the size of the earth, yet his revolution only takes 10 hours. If these cloud accumulations are produced by the revolution of the planet, the velocity of the currents must, therefore, be something enormous. Some of the markings on the planet Jupiter have been seen to recur years after, and we cannot conceive of any peculiar cloud-form recurring after a number of years. It seems probable that something solid has been seen on these occasions. We cannot expect cloud-forms to have that definite character and to retain it. His own opinion was that the great changes which had occurred within short intervals were simply changes in the state of definition, not changes on the planet, but changes in our power to see it. He had lost sight of certain features one night, and seen them another night.

In June, when we had a great change in the state of our atmosphere, the colour of the planet was altered. He thought the colour of the planet depended on the state of the air over our heads. The colours of the stars depend on something very mysterious. Being struck with the differences of colour observed through different telescopes, he had put a graduated scale of colours, varying from green to red, through yellow and orange. Through the telescope there came to view a definite point at which the yellow changed to pink—a point not visible to the naked eye at all. With a silver-glass reflecting telescope he observed the same phenomenon. He could only explain this by supposing that the pink had been put over the yellow.

Mr. Hirst said that, as to the sudden disappearance of some of the markings, the remark of Mr. Russell was hardly borne out by some existing observations. Sir James South mentioned that a black patch on Jupiter, representing a space on the planet 22,000 miles in diameter, totally disappeared in the course of a few minutes. Such a conspicuous marking could scarcely be blotted out in a moment by bad definition.

Part I.

ON THE GENUS CTENODUS,

A FISH FOUND IN THE TRUE COAL MEASURES OF GREAT BRITAIN.

By W. J. Barkas, M.R.C.S.E., L.R.C.P.L.

[*Read before the Royal Society of N.S.W.*, 6 *September*, 1876.]

Knowing that very few persons are acquainted with the fossil ichthyology of the Carboniferous formations of Great Britain, even in Great Britain itself, it is perhaps necessary that I should state at once my reasons for introducing a paper before this Society upon a subject that is apparently foreign to this Colony and to all Australasia, for undoubtedly *Ctenodus* is not found anywhere in this part of the world. *Ctenodus* is a fish that existed during the Carboniferous era of Great Britain's history in comparatively large numbers, but inhabiting, so far as our present knowledge extends, only a very small area of its waters. Fishes of the same genus, but of different species, are found in the Old Red Sandstone, but they are very rare, and are even more limited in their habitat than the Carboniferous *Ctenodi*, judging, of course, from the scarcity of their remains that have been brought to light by geological research during a goodly number of years. Prior to the Devonian period we have not any trace of this fish, nor have any remains been discovered in formations that have been formed since the Carboniferous epoch; it was, therefore, considered to be a form of animal life that had become totally extinct at the close of the Coal Measure era, not having any counterpart in the different stages of the world's formation after that time. Although there was not, at the time of the first discovery of the remains of this fish, any known living type by which its place in the order of Being could be verified, the great palæontologist Agassiz at once classified it among the Fishes, for all that he had only been able to examine a few dental plates. Since the time of the discovery of the dental plates seen by Agassiz, extensive researches have been made into the Natural History of the World as it exists at present, and among these inquiries were some that were directed to the ichthyology of Australian seas and rivers. It was not long before the Hon. Wm. Forster obtained a fish from some

Australian river that was markedly different from all other known existing species,* and this fish was named *Ceratodus Forsteri* by Mr. Krefft, late Curator of the Sydney Museum, and I understand that he published an account of it in the Second Part of the Proceedings of the Zoological Society for 1870, but I have not had the opportunity of seeing the paper. Dr. A. Günther was the first, I believe, to give a full description of *Ceratodus;* this he did in the Transactions of the Philosophical Society for 1871. It was at once seen by palæontologists and ichthyologists that the detached dental plates called *Ctenodus* by Agassiz closely resembled those of *Ceratodus* in their configuration, and they drew the inference that *Ceratodus* and *Ctenodus* probably belong to the same family. Further researches into the Coal Measure shales brought to light other remains of the fossil fish, and these mineralized portions of the endo- and exo-skeletons were also seen to resemble closely similar parts of the recent fish. The fact, therefore, that *Ctenodus* is evidently the prototype of a fish found only in Australian waters at the present day is my apology for introducing this paper; which fact is rendered all the more worthy of attention when we think of the immense æons of ages that must have passed away since the Carboniferous period, during which time we have no trace of either *Ctenodus* or *Ceratodus*, nor of any allied form.

Ceratodus is, I suppose, tolerably well known to most of the ichthyologists of Australia, I shall therefore refer to it comparatively seldom, my principal object being to describe what is known of *Ctenodus*, and incidentally only will I point out the resemblances between those fishes.

Concerning the remains of *Ctenodus*, I am well able to speak; for Mr. T. Atthey, Mr. T. P. Barkas, F.G.S., and myself, have probably the most complete collections of them in the world, in fact, I know of no other Coal Measure palæontologists nor any Museum that have any other remains than the teeth, unless they have obtained them from the two first-mentioned gentlemen. I brought out specimens of the remains with me from England, but unfortunately some of them have been irreparably injured by the severe knocking about my boxes received while being carried from Sydney to Bombala, my present residence. Sir Philip de Grey Egerton obtained numerous specimens from my father, Mr. T. P. Barkas, which he intended for our Sydney Museum, but on inquiry I find that they have not been received, from some cause or other.

Ctenodus was so named by Professor Agassiz from some dental plates discovered in the Old Red Sandstone and Coal Measures;

* Since this paper was written I have been informed that the Rev. W. B. Clarke and Mr. A. W. Scott were the first to discover this fish's close resemblance to Agassiz's extinct genus, at least so far as the teeth are concerned.

he classified it among the Fishes as a Placoid; but, beyond naming the genus and species, he did little more; what remarks he makes will be found in his "Poissons Fossiles" tome iii. The species he founded were *C. alatus* and *C. asteriscus* from the Devonian formation, and *C. cristatus*, *C. Murchisoni*, *C. Robertsoni*, from the Carboniferous. Professor Owen falls into the same error with regard to the classification of this fish. That Agassiz and Owen should have erred in thus classifying *Ctenodus* is not to be wondered at, for they were only acquainted with the dental plates, and had no other fish presenting teeth of this type to refer to; any ichthyologist having only the teeth before him would make the same mistake, for they are unmistakeably *Cestraciont* in character. Hugh Miller, while examining *Dipterus*, another Devonian fish, discovered that it possessed teeth similar to those of *Ctenodus;* this discovery tended to show that Agassiz and Owen were mistaken in considering *Ctenodus* to be a *Placoid*, as *Dipterus* is, without doubt, either a member of the *Ganoidei* or the *Dipnoi*; the majority of palæontologists at present placing it as a *Ganoid*. Other fish remains were obtained, and named *Ceratodus* and *Tristychopterus*, with similar teeth. These four fossil genera, *Dipterus*, *Tristychopterus*, *Ceratodus*, and *Ctenodus*, were arranged by Professor Huxley, in his synopsis of the Ganoidei, in a family, which was named, *Ctenododipterini* by Professor Pander, having the following characters:—Two dorsal fins placed far back; acutely lobate pectoral and ventral fins; no branchiostegal rays; jugular plates; single anal fin; caudal extremity tapering to a point; lower lobe of tail much larger than upper; scales cycloidal and smooth; bones of cranium anchylosed into a shield; lower law of peculiar form; dentition ctenodont. Eichwald, in the first volume of his "Lethæa Rossica" further adds that *Ctenodipterines* have solid and distinct bodies in their vertebræ, and that their scales are rounded and imbricated besides being cycloidal. Dr. A. Günther, in his paper to which I have already referred, seems clearly to prove that *Ceratodus* belongs to the *Dipnoi;* if this be so, then *Ctenodus* must also do so, for these two fishes in their internal skeleton are similar in every respect so far as we know as yet; the complete tail of *Ctenodus* has not been discovered up to the present time, it may possibly differ from that of *Ceratodus*, but seeing that the fishes agree so far as their bony remains are concerned, it is not probable. However, while there is this uncertainty we will not dogmatize upon the matter, but will leave it an open question to be decided by future discoveries; still, it may safely be predicated that *Ctenodus* is related to whatever family *Ceratodus* may belong. From a private letter that I received in May last I learn that Professor Huxley has been lecturing during the past winter upon the relationship between *Ceratodus* and *Dipterus*, but, strange to say, he never spoke of *Ctenodus*, which is even more closely allied to *Ceratodus*.

The teeth are the parts of the fish *Ctenodus* that are most frequently discovered, and they have been obtained in places where no other remains of the endo- or exo-skeleton have been observed; they are most common in the true Coal Measures of Northumberland; occasional teeth are disinterred from the coal formations of South Yorkshire and Staffordshire; a single tooth has been obtained from the carboniferous limestone of Derbyshire; and there is a single specimen in the British Museum that is believed to have been found in the Coal Measures of Carluke, in Scotland; if the latter be a fact, then Carluke is the outermost limit of this fish's geographical range to the north, and Derbyshire is known to be the southern boundary; but even within this confined area the strata containing the remains are very small in extent; for example, Northumberland is the most prolific in its supply, yet nearly all the specimens are obtained from a pit at Newsham, the remainder being found at Cramlington; the same thing is observed in Staffordshire. Besides the narrow range of this fish, we can also judge that its habitat was in the shallow brackish waters of estuaries, and the mixed waters of the sea near the mouths of rivers; for we find its remains fossilized in the shales, in which are also imbedded numerous *Cestracionts* and *Ganoids* that certainly did not exist in fresh water, although they frequently roamed into the deep seas; such are *Cladodus*, *Psammodus*, *Palæoniscus*, *Rhizodus*, &c. To this fact there appears to be an exception. I refer to the tooth found in the Derbyshire limestone, that seems to prove that *Ctenodus* was also a deep-sea fish, but a little thought will show its improbability; only one tooth has been obtained from that stratum, notwithstanding the extensive researches that have been made into it; the tooth has, therefore, been most probably carried out into the deep sea by a strong under-current, or a solitary fish may have strayed out and died from inability to exist in a foreign water, leaving its remains to decay or become imbedded in the forming limestone. That *Ctenodus* did not live in fresh water is clearly proved by the fact that the shale containing these teeth has never been observed, by me at least, to contain fossilized terrestrial or fresh-water vegetation. So much for the classification, geographical range, and habitat of *Ctenodus*. We will now turn to the fish itself, and in this paper I shall confine myself to the teeth, describing the characters of the different species and illustrating them by drawings. In future papers I shall pourtray their microscopical structure, draw attention to the characters of the bones that enter into the formation of the mouth and the mode of arrangement of the teeth, and finish by describing the endo- and exo-skeleton.

C. cristatus was the first species named by Agassiz, and was founded upon a tooth at present in the Leeds Museum; Mr.

T. P. Barkas, and, I believe, Mr. Atthey also possess perfect specimens in their cabinets. The tooth was imperfectly described by Professor Agassiz in his "Poissons Fossiles," but tolerably figured. Professor Owen referred to the genus in his "Odontopography" among the *Cestracionts;* and, if I mistake not, for I have not the book at hand for reference, the tooth he figures, and figures well, is one of *C. cristatus*; but his remarks on the external characters are too brief to be called a description, while his sketch of the minute structure is quite inaccurate. Messrs. Hancock and Atthey, in a paper entitled "Notes on various species of Ctenodus obtained from the Northumberland Coal Fields," which appeared in the third volume of the "Transactions of the Northumberland and Durham Natural History Society," were the first palæontologists to give a complete description, and it may be summed up as follows:—Tooth plate-like; rather thin; irregularly elliptical; inclining to ovate; 2¼ inches long, 1⅛ inch broad (these measurements are, of course, average); the upper surface somewhat hollowed or concave; inner margin well arched, the outer much less so; upper surface is covered with twelve close-set transverse ridges, which are studded from end to end with closely arranged tubercles; ridges increase in size externally and incline towards the anterior and posterior margins, thus appearing to radiate; grooves angulated; tubercles perfect only on outer margin and are covered with brilliant enamel; base of each tubercle subtriangular; the imperfect tubercles are much worn and compressed laterally; tubercles and ridges coarsely and irregularly granular. Mr. T. P. Barkas, F.G.S., briefly describes his specimen, in a paper on "Ctenodus," which appeared in the "Geological Magazine" for July, 1869.

C. Robertsoni is only referred to by Agassiz himself in the "Poissons Fossiles"; he neither describes its external character nor does he figure them; but he refers slightly to its microscopical characters, and attempted to pourtray them; the description and engraving are, however, nearly valueless from the meagreness of the one and the low power of the microscope that has been employed in examining the other.

C. Murchisoni was named by Agassiz, but neither described nor figured by him; and Pictet merely gives the name and founder of the species in the second volume of his "Traité de Palæontologie."

C. alatus, from the Old Red Sandstone, is merely mentioned by name by its first observer, Agassiz, in his "Poissons Fossiles."

C. asteriscus (Agassiz), also from the Old Red Sandstone, is just hinted at by name by Giebel in his "Fauna der Vorwelt."

The four last-mentioned species may or may not be true species for anything I know to the contrary; and I am not aware that any palæontologist who is acquainted with the recent discoveries

of the teeth of different species of *Ctenodus* has ever seen them; and, as I have said, neither descriptions nor figures are extant for comparison.

C. tuberculatus was discovered by Mr. T. Atthey, in the shale of the Low Main coal seam in Northumberland, and was so named by him. The discoverer, in conjunction with the late Mr. Albany Hancock, F.L.S., describe its teeth fully in the "Notes" that I have already referred to. The following is a brief epitome of the external characters of the tooth; plate-like; thick; irregularly ovate; 2¾ inches long; 1⅛ inch broad, but they vary a little in size, the specimen I figure is 2½ inches long and 1⅜ broad; narrow posteriorly; inner margin gibbous or angulated in the centre; outer margin a little convex; upper surface slightly convex, with from twelve to eighteen ridges traversing it, deep, sharp, parallel and approximate, strongly tuberculated towards the outer margin; grooves narrow, deep, and angular; ridges arched posteriorly and enlarged towards the external border, but they are not radiate; anterior ridge widest, and is reflected and prolonged somewhat beyond outer margin; tubercles conical with obtuse points, those near the outer border are coated with brilliant enamel and are well-produced; mandibular tooth narrower than palatal and very convex. From this description it will be seen that this tooth differs from *C. cristatus* in being convex, and in having sharp and deep ridges, and by the form of the tubercles. Messrs. Hancock and Atthey gave an illustration of this tooth in the fourth volume of the "Transactions of the Northumberland and Durham Natural History Society," but Mr. Barkas figured it previously in the sixth volume of the "Geological Magazine," and at the same time a drawing was given of a tooth in the British Museum, with a few remarks by the editor. Mr. Barkas also gives excellent lithographs in the "Atlas" to his "Coal Measure Palæontology." Mr. Miall of Leeds gave it as his opinion, in the Annals of Natural History, fourth series, volume 15, that there is not any difference between the teeth of *C. tuberculatus* and *C. cristatus*. I cannot help thinking that that gentleman has never seen a true tooth of the former fish or he would never have uttered this opinion, for they undoubtedly differ very much, but it is possible that they might belong to the one species, the one tooth being mandibular and the other palatal, but this is not probable, as *C. tuberculatus* is comparatively common while *C. cristatus* is very rare; nor have they ever been found on the same slab of shale; groups of the teeth of *C. tuberculatus* have been discovered which tend to show that the mandibular and palatal teeth are similar, the latter differing from the former in being narrower only; we must, therefore, for the present at least, consider these two varieties of teeth as belonging to different species. Fig. I. is a specimen of a tooth of

C. tuberculatus from the cabinet of Mr. T. P. Barkas. Alter the convexity to a concavity and shorten the external ridge to a uniformity with the others, and we would have an almost perfect figure of *C. cristatus*.

C. obliquus, Atthey. From the Northumberland Coal Measures, is a comparatively common species. It has been described and figured by Messrs. Hancock and Atthey in the third and fourth volumes of the "Transactions" I have already alluded to, and by Mr. Barkas in "Coal Measure Palæontology." Externally the tooth is plate-like; depressed; lanceolate; $1\frac{1}{2}$ inch long; $\frac{5}{8}$ inch broad; inner margin regularly and much arched; outer border slightly curved; six or seven strong, compressed, sharp-edged, transverse ridges, radiating somewhat towards the external margin, where being enlarged they curve downwards and are denticulated; anterior ridge very oblique, being much inclined forwards; tubercles much compressed laterally, lancet-formed with sharp points, coated with brilliant enamel; mandibular tooth narrower than palatal, is broadest in front, tapering pretty regularly posteriorly, anterior ridges very wide and much produced beyond the others, all the ridges are curved downwards, and vary from $\frac{3}{8}$ of an inch to $1\frac{1}{3}$ inch in length. In figure II. I have pourtrayed this tooth.

C. elegans, Atthey, is the commonest species found in the Northumberland carboniferous shales, and it is also the smallest variety. It was described in the "Notes" of Messrs. Hancock and Atthey, but was not figured. Mr. Barkas illustrates it in his work, and I herewith give a drawing of a very large specimen, Fig. III. The tooth is plate-like, depressed, triangular, averaging $\frac{3}{8}$ of an inch in length and $\frac{3}{16}$ of an inch in breadth; inner margin produced and angulated in centre, from whence it slopes anteriorly and posteriorly towards the outer margin, which is slightly arched; seven to eight strongly denticulated ridges which radiate from the angle, at which point they are very minute; anterior ridge a little produced; six or seven denticles on each ridge, which are much compressed laterally, sharp-pointed and lancet-like, with inner limb a little shouldered, where there is occasionally a minute toothlet; ridges and denticles brilliantly enamelled. Professor Owen, in his booklet on the "Dental Characters of Carboniferous Fishes and Batrachians," founds a new genus, *Sagenodus*, upon some sections he had sent to him, but he never saw the original teeth; the structure exhibited by the microscope of these sections presented features quite new to him, and he accordingly designated the tooth *Sagenodus inequalis*. In this work he gave excellent illustrations of the structure, and it is similar in every detail to the microscopical appearance of *C. elegans*, which had been described fully long previously.

C. corrugatus, Atthey, was discovered in the coal shales of Northumberland. It was described by Messrs. Hancock and Atthey in their "Notes," but it has never been figured. Its characters are as follows (it must be remembered that my descriptions of the teeth discovered and named by Mr. Atthey are summaries of his remarks. I may state, however, that I possess or have examined specimens of each of his species): plate-like; thin; sub-triangular; three inches long, two inches broad; upper surface slightly convex, with nine stout, somewhat irregular rounded ridges; grooves wide and rounded; ridges die out as they approach the internal and external margins, but they are slightly enlarged at the external extremities, and are indistinctly and irregularly tuberculated; inner margin nearly straight; outer border slightly convex; anterior edge slopes forward from inner margin; posterior border produced and rounded; surface strongly and irregularly punctated. The distinguishing features of this tooth are the fewness of the ridges, their roundness and wide separation, its great size and general form.

C. octodorsalis, T. P. Barkas. From the Northumberland coal seams, was described in the second volume of "Scientific Opinion," but it was not illustrated. Its characters, according to Mr. Barkas, are:—length, two inches; width, one inch; eight ridges free from denticulations; at the extremities of the first six ridges there are slight depressions which indicate two rudimentary tubercles; the seventh ridge is drawn to a point, and the end of the eighth ridge is flat and chisel-shaped; the grooves between the ridges are broad, and their bases are shallow and smoothly rounded.

C. concavus, T. P. Barkas, is only founded provisionally, for its founder has occasion to think that it may be an unusual form of *C. tuberculatus*. It was discovered in the Coal Measures of Northumberland. The tooth is 2¾ inches long, 1¼ inch broad, very concave from without inwards, and presents the appearance of a large segment of a cylinder; the external edge is nearly straight; the internal margin resembles the side of an ellipse; the ridges are eleven in number, and extend across the body of the tooth at right angles with the front; the ridges are deep, angulated, and slightly curved; the anterior ridges are broad, and the remainder gradually narrow towards the posterior extremity of the tooth; except at the external extremities of the ridges, they are free from tuberculations; the crest of the anterior ridge is very convex, the others very concave; anterior ridge has two well-developed and two rudimentary tubercles; the second three well-defined; third, fourth, fifth, sixth, seventh, have one each; the eight has two, and the remaining ridge one; each external tubercle on first, second, and eighth ridges are covered by brilliant cream-coloured enamel; the rest are dark, and highly

polished; between the ridges and the plate of attachment there is a distinct line of pale enamel surrounding the tooth; the plate of the tooth is thin; under surface as convex as upper is concave. A description of the tooth appeared in the second volume of "Scientific Opinion," and an illustration was given in "Coal Measure Palæontology." In my opinion this tooth more closely resembles *C. cristatus* than *C. tuberculatus*. Fig. IV. is a copy of Mr. Barkas's lithograph.

C. monocerus, T. P. Barkas. From the Northumberland Coal Measures. It was described and figured in the paper and book just referred to. The tooth is 2½ inches long; 1¼ inch broad; five bold radiating ridges; first ridge projecting forward at an angle of 30 degrees, second at 45 degrees, third at 60 degrees, fourth at right angles to the base, fifth inclined backwards from the perpendicular 15 degrees; ridges smooth; tip of first ridge lost; second, third, and fourth ridges have each two highly enamelled tubercles at their extremities; fifth ridge one tubercle; the plate extends beyond the 5th ridge with an undulating surface for half an inch, and is symmetrically rounded off; upon the front of the tooth and opposite the groove of the fifth ridge is a large mammillary tubercle or horn which distinguishes this tooth from any other species. Fig. V. is a copy of the published drawing.

The teeth I have described so far have all ridges that are more or less tuberculated; those I now intend to refer to are without tubercles, and therefore more closely resemble the teeth of *Ceratodus*.

C. imbricatus, Atthey. From the Northumberland Coal Shales, was described in the 3rd, and figured in the 4th volumes of the Northumberland and Durham Natural History Society Transactions, by Messrs. Hancock and Atthey. The palatal tooth is depressed; very thick; slightly concave; 2¼ inches long; upwards of 1 inch broad; inner margin well and regularly arched, the anterior slope being much longer than the posterior: outer margin nearly straight and coarsely serrated by the ridges projecting; 6 ridges, which enlarge rapidly towards the outer margin, strong, smooth, somewhat distant from each other, and though mostly inclined forwards, are laid over towards the posterior end, having an imbricated appearance; grooves angulated, surface minutely granular, edges enamelled. Mandibular tooth very narrow and fusiform; ridges not imbricated and grooves scarcely angulated. Fig. VI. is a copy of Mr. Atthey's engraving. As my specimens are in England I cannot make an original sketch.

C. ellipticus, Atthey. From the Northumberland Coal Measures, was described in Messrs. Hancock and Atthey's "Notes." Palatal tooth flattened; thin; elliptical; 1¼ inch long; ¾ of an inch broad; inner and outer margins irregularly arched; 5 transverse, smooth, distant, angular ridges, increasing in size

externally; grooves wide and round, anterior and posterior margins extended a little beyond the ridges, surface minutely punctated; mandibular tooth narrow and inner border gibbous, otherwise is the same as the palatal. No drawing has been published, and I cannot illustrate the tooth, for the reason given above.*

C. obtusus, T. P. Barkas. From the Northumberland Coal Measures. The palatal tooth was described by Mr. Barkas in the 4th volume of the "English Mechanic." The tooth is strong; flat; approximately ovate; 1⅓ inch long; 1 inch broad; inner margin regularly arched; outer margin has a wave-like serration arising from the roundness of the extremities of the projecting ridges; the four posterior ridges and their accompanying furrows have an undulating appearance, the grooves and ridges being equal in width; the anterior ridge is broad, flattened, and slightly concave; upper surface boldly punctated and ridged, the edges of which have a tendency to inosculate; much of the surface has, therefore, a reticulated appearance. Mr. Barkas adds—"That the only tooth with which it is likely to be confounded is *C. ellipticus*, but a very slight examination will show the contrast that exists between them."

C. quadratus, T. P. Barkas. From the Northumberland Coal Measures, was described in the 18th volume of the "English Mechanic," but it has not been illustrated. The teeth of this species vary slightly in size, but the tooth I figure in Fig. VII is about the average; the inner margin is bent almost at right angles, a little external to its centre; the outer margin is also bent about the same place, but not so abruptly, possessing more of a curve; this peculiarity of the margins gives the tooth a quadrate form; the outer margin is irregularly waved from the ridges projecting beyound it; the ridges, six or seven in number, radiate from the inner angle; they are not tuberculated, being smooth and angular; upper surface finely pitted and showing a tendency to reticulation.

C. ovatus, T. P. Barkas. From the Carboniferous Limestone of Derbyshire. Only one tooth has been discovered; it was described in the 2nd volume of "Scientific Opinion," and was figured in "Coal Measure Palæontology." I have not the founder's description at hand, but I herewith give a copy of his lithograph, Fig. VIII.

C. interruptus, T. P. Barkas, was founded on a tooth in the York Museum, and was described in the same paper as *C. ovatus*. I cannot describe this species, for I have never seen it, nor has it been figured, and as I have said, I have not at present access to the 2nd volume of "Scientific Opinion."

* This tooth has the greatest resemblance to a tooth of *Ceratodus*; the latter tooth has six ridges instead of five, the plate does not extend beyond the anterior and posterior margins, nor is it so large.

C. caudatus, W. J. Barkas. From the Northumberland Coal Measures. The specimen that I pourtray in Fig. IX is the only one that has been discovered as yet. It resembles *C. ellipticus* to a certain extent, but it differs in being smaller and in having a long projection from one extremity; this prolongation is not the result of a fracture nor is it a fold of shale, for I have freed the tooth completely from the matrix of shale; the posterior ridges are rather indistinct, having probably been worn away during life; but traces are left of four non-tuberculated ridges; the anterior ridge is broad, much inclined forwards, and projects beyond the outer margin; the under surface is smooth, and a ridge runs horizontally along its centre from the back of the prolongation; the tooth is 1 inch long, including the tail, and ¼ of an inch broad.

I have now described the characters of the teeth of every species that has been discovered, and with which I am acquainted. In my next paper I shall refer to the microscopical structure of these teeth, and illustrate it by drawings taken with the camera. Fortunately all the teeth I have described possess the same structure, there will, therefore, not be any necessity to go over all the species in detail again. My further programme is to pourtray the incisive or vomerine teeth, the mandibular, palatal, and articular bones, and the dental arrangement; next, the head bones, ribs, operculæ, &c., &c. By this means all that is known of *Ctenodus* will be brought together for the first time into a series of consecutive papers, and comparisons with the similar parts of *Ceratodus* will then be more easily made.

In order that comparisons may be at once instituted between the teeth of *Ctenodus* and those of a recent *Ceratodus*, I herewith append Dr. Günther's description of the external characters of the teeth of the latter fish, which appeared in a paper on Ceratodus in the "Philosophical Transactions," Part II, for 1871:—

"Each maxillary dental plate is an oblong piece, with a grinding surface, a convex inner side, and with the outer side divided into six prominent trenchant ridges or prongs, by five notches, of which the foremost is the deepest, the others becoming shallower posteriorly. The foremost ridge passes to the inner border of the tooth, which is likewise somewhat raised. The grinding surface has a great number of minute depressions or punctuations. The total length of a maxillary tooth is 1¼ inch, and its greatest width ½ an inch. In form and size the mandibulary teeth are very similar to the maxillary, only the grinding surface is less uneven. These teeth are anchylosed to the bone, and inserted in an oblique direction—the upper teeth nearly meet each other in the median line, but there is rather a wide interspace between the lower." Fig. X. is a maxillary tooth copied from Günther's monograph, plate XXXIV, fig. 3.

Discussion.

The Rev. W. B. Clarke, Chairman, said that Dr. Barkas had studied the *Ctenodus* chiefly from the teeth, and had compared these with the teeth of *Ceratodus*. When he (Mr. Clarke) first saw the recent *Ceradotus* he examined the teeth, and pointed out to the Curator of the Museum that it was a *Ceratodus*, referring him to the plates in the *Poissons Fossiles* of Agassiz. Sir C. W. Thomson had also shown him fossil teeth of *Ceratodus* found embedded in the soil of Queensland. In the Geological Magazine for 1869 the father of Dr. Barkas had described the teeth of various species of *Ctenodus* found in the Coal Measures of Northumberland, and of some of these teeth figures were given as shown in the Magazine, vol. VI, produced.

There was a difference between *Ctenodus* and *Ceratodus*, yet they were related. It was a marvellous fact that a fish of such antiquity in Europe as *Ceratodus* should be found living at the antipodes. Mr. Clarke then exhibited to the meeting teeth of *Ceratodus* of several species from Wurtemburg.

Part II.

ON THE MICROSCOPIC STRUCTURE OF THE MANDIBULAR AND PALATAL TEETH OF CTENODUS.

By W. J. Barkas, M.R.C.S.E., L.R.C.P.L.

[*Read before the Royal Society of N.S.W.*, 4 *October*, 1876.]

In my last paper I described the external characters of the teeth of all the species of this genus that have been discovered, and hinted at the classification and probable distribution. To-night I shall draw your attention to the minute structure of the teeth, and as I find from my investigations that they possess a similar structure in all the species, I shall take *C. tuberculatus*, this species possessing the largest teeth and being the most common, as a typical tooth. *C. elegans* apparently differs in structure but in reality it does not do so, as I shall show in the course of my remarks.

Professor Agassiz, while describing the different species in his "Poissons Fossiles" that were known to him at the time of publication of that great work, refers to the structure of *C. Robertsoni* only, leaving it to be conjectured that it was the only species he

examined, or that the other teeth had a similar formation; he figures a section magnified a very few diameters, which only shows the medullary canals branching and anastomosing in an homogeneous matrix, and such is the opinion the Professor held of the minute anatomy, for he distinctly states that there are not any calciferous tubules nor canaliculi (*sic*) permeating the osseous part of the tooth. Undoubtedly he was right in pourtraying what he saw, but we will see shortly that even with a low power dentinal tubules can be easily perceived, and that when they are absent it is because of the thinness of the section.

Professor Owen, in his "Odontography," remarks that the texture presents a coarse osseous base supporting a dense osseous or enamel-like layer, which statement is very indifferent and might be applied to a great number of the teeth of Cestraciont genera and species. Many years after the appearance of this work, Professor Owen published a booklet entitled "On the Dental Characters of Carboniferous Fishes and Batrachia," but which was immediately withdrawn from circulation, as it was at once seen that every tooth he described and had raised into a new genus or species had been known, named, and described years previously. Among these so-called new genera was *Sagenodus*, the species *inequalis*, the description of which was accompanied by beautifully coloured lithographs, but neither the letter-press nor the figures differed in one essential point from the account of *Ctenodus* structure as published by Messrs. Hancock and Atthey in the "Annals of Natural History" and the "Transactions of the Northumberland and Durham Natural History Society."

A somewhat brief description of the minute structure of these teeth was given by Messrs. Hancock and Atthey in a paper entitled "Notes on the Remains of some Reptiles and Fishes from the Shales of the Northumberland Coal Field," which appeared in the 3rd volume of the above "Transactions"; they took *C. cristatus* for their purpose; they, however, did not figure the structure.

Mr. T. P. Barkas does not refer to the microscopical characters in any of his writings on this subject, but he gives coloured lithographs of them in the "Atlas" accompanying his "Coal Measure Palæontology."

This is all the literature bearing upon this portion of my paper, and it will be seen that it is too meagre for purposes of comparison; the figures, however, of Agassiz and Barkas are excellent considering the low powers they employed. As I have said, the structure of the teeth of *Ctenodi* is similar in detail whatever species may be taken, but undoubtedly they can be made to differ markedly to all appearance by cutting sections in different situations and directions, but when a section of a tooth of one species is compared with an exactly similar cutting of the tooth of another these differences disappear.

But before entering into the microscopical structure I wish to quote Dr. Günther's remarks on a vertical section of a tooth of *Ceratodus*, as the characters he describes are identical with those of a tooth of *C. tuberculatus*, *C. cristatus*, &c. "In a vertical section of one of the grinders it is seen that the real depth of the tooth (that is, that portion which is formed by dentine) is much less than it appears from a merely outward inspection. It rests, in fact, on an elevated plateau of the dentary bone, which has exactly the same outlines as the tooth itself, and the substance of which passes so gradually into that of the tooth that it is only by the difference in the shade of colour that the boundary between osseous base and dentinal crown is indicated. This anchylosis, however, is limited to the circumference of the base of the tooth; for its central parts are separated from the bone by the extensive but shallow pulp-cavity. We must remember that our specimens of living *Ceratodus* are by no means aged individuals, certainly much smaller and younger than those gigantic individuals of extinct species must have been, of which teeth two and more inches long are preserved. In such fossil teeth no pulp-cavity is visible, but the dentine passes into the bone across the whole base of the tooth. It is not at all improbable that the pulp-cavity disappears altogether with age." The last remark concerning there not being any pulp-cavity in the teeth of fossil *Ceratodi* certainly does not apply to the teeth of *Ctenodi*, for I have examined vertical sections of teeth of *C. tuberculatus* that displayed just as distinct pulp-cavities as we see in similar sections of the teeth of *Ceratodus Forsteri*, and others again that exhibited no trace of such spaces. Dr. Günther's hint as to the presence or absence of a pulp-cavity being an indication of age is, in my opinion, undoubtedly true when applied to the teeth of *Ctenodus*.

A vertical section of *C. tuberculatus* taken either from before backwards, or from side to side, when slightly magnified, shows that the osseous tissue of the tooth is exceedingly freely permeated by medullary canals, which are very large in diameter, and which branch and anastomose with each other frequently but yet in a very irregular manner, so that the tissue presents an appearance of a network of vessels, the meshes of which vary much in size. Though this is the aspect observed in a brief glance, a closer inspection makes evident that there is a tendency of the canals towards a certain course, and towards a regular method of branching also, in some parts of the tooth; for the arrangement of these tubes varies according as to whether we examine the base, or plate as it is usually termed, or the ridges with their tubercles. We have in these two parts fundamental differences of structure, apart from the characters of the canals, the plate possessing certain features found in true bone structure, while the ridges present characteristics that are purely dental.

The base or plate when cut vertically and examined under moderate powers, presents large canals traversing the bony substance, and which gives off branches at all sorts of angles. These branches vary slightly in length, but they are always short and soon anastomose with each other. The irregular branching and ready inosculation, combined with the fact that the diameters of the branches are quite as great as those of the main vessels from which they arise, cause the base to appear riddled with an irregular open network of vessels; nor does this character alter when the base is taken horizontally, thus showing that the canals at this point have not any particular course. The proportion of bone tissue to canals is about equal. The canals in this part of the tooth do not give off any ramuscles to penetrate the osseous substance. The bone, however, is supplied with nutriment by means of lacunæ. These lacunæ, or bone-cells, are characteristic of true bone; but in this tissue they differ from those of true bone in their form and arrangement. They are numerous, and are not arranged in concentric circles round the canals, but are dispersed throughout the bony tissue in an irregular fashion. In size the bone-cells are large, and present more of a reptilian character than of a piscine. In a vertical section the lacunæ have an exceedingly elongated form, the long diameter being frequently parallel with the course of the medullary canals they accompany; but often they lie without any such order. When cut transversely through the centre the cells assume an almost circular form. The bone-cells vary somewhat in length and breadth. All the lacunæ give off canaliculi, which ramify in the osseous substance, and inosculate with canaliculi springing from neighbouring lacunæ or else empty themselves into the adjoining canal. In order to examine these lacunæ with their canaliculi, it is not necessary to use high powers on account of their size, but they are often absent in sections, this being due to the cuttings having been made too thin, and the lacunæ ground away altogether. The bone tissue is homogeneous, no structure being observable under any power of the microscope.

As we follow the network of medullary canals to the upper surface of the plate we find that it gradually assumes a more regular appearance from the canals becoming smaller in diameter and pursuing a more vertical course near the junction of the plate with the ridges; the network slowly changes and becomes obliterated. This alteration is caused by the branches that are given off by the main canals arising at a more and more acute angle, and pursuing a more and more vertical course, thus necessitating anastomoses of the branches with each other at higher points than their places of origin—the branches still present a similar diameter to the parent canals. The bone tissue at the same time becomes more and more out of proportion to the

canals, that is, it increases in quantity, but the addition is never in great excess, the sections, whether vertical or transverse, always having an open structure. The bone substance still remains homogeneous, but it often presents a laminated appearance immediately surrounding the canals; lacunæ are to be seen, but they are much smaller, more rounded, and few and far between.

On a level with the bases of the ridges, the network character of the medullary system is quite lost, and the structure of the ridges and tubercles presents a totally different arrangement from that of the base; when a low magnifying power is employed for observation the change seems to be sudden. The canals are now much decreased in diameter, run in a somewhat vertical manner, give off branches at a very acute angle, which anastomose with each other very freely after pursuing a short vertical and oblique course. From these causes, a section when examined appears filled with very short vertical tubes, as is portrayed in Fig. X., which is a vertical section of a tubercle of *C. tuberculatus* magnified 20 diameters. The osseous substance immediately surrounding the medullary canals is laminated, and the concentric rings are darker in tint than the unlaminated portion of the tissue; the whole, however, is homogeneous, and the lacunæ have disappeared. From the canals spring numerous dentinal tubules, which run a very short course and branch once or twice on their way in a dichotomous manner. The tubules of one canal inosculate by their terminal branches with those of a neighbouring canal, and they also undoubtedly anastomose with the tubules adjoining that arise from the same main vessel. These tubules are often not visible in sections, sometimes from the Canada balsam, which has often the same degree of refrangibility as the fossil substance, permeating them, but more frequently they have been ground away in attempting to make a thin section. Fig. XI. represents a portion of a medullary canal cut vertically, and shows the laminated character of the osseous tissue adjoining, and the tubules springing from the canal as seen under a magnifying power of 250 diameters. The structure I have just described is present throughout the ridges and tubercles.

Immediately external to this tubular portion of the ridges and tubercles on the upper surface of the tooth is a thin layer of dense tissue, unpermeated by the medullary canals or their tubuli, and apparently without structure. When an unworn tooth is examined there is perceived external to the above dense layer a coat of ganoine or fish enamel, which is also structureless; this covering, however, is rarely seen, for it appears to have been very easily worn away by the friction which trituration of hard substances with teeth like these would cause.

It only remains for me to notice *C. elegans*. On account of the extreme thinness of the plate of the tooth of this fish, it is impossible to cut vertical sections similar to those we have employed in observing the structure of the teeth of the other species of *Ctenodus*. Even in taking transverse sections, it matters not how carefully one may attempt to make them, it is also impossible to cut below all the tubercles, which are large compared to the size of the tooth; we have, therefore, an appearance presented to us of bulbous ridges; in Fig. XII, however, the first ridge has been taken pretty fairly, the bulbous aspect only appearing near its apex. In a section like this we still find the two varieties of structure that we noticed in *C. tuberculatus*; Fig. XII, however, does not exhibit the network character of the medullary canals in the base of the plate of the tooth; but I have observed that feature in other specimens that have been more fortunately ground; it does illustrate, though, the vertical tendency of the course of the canals in the upper part of the plate and in the ridges and tubercles, for both Figs. XII and XIII show them cut transversely across as they were proceeding towards the upper surface. From these canals dentinal tubules are given off which ramify in the clear osseous tissue that is observable in the centre of each tubercle. The peculiar radiate form of the bone substance in the centre of the tubercles is due to the medullary canals grooving the mass on their course upwards, leaving processes of clear transparent bone between them. External to the medullary formation we have the layer of dense tissue, and covering that, in unworn specimens, there is a coat of enamel.

Part III.

ON THE VOMERINE TEETH OF CTENODUS.

By W. J. Barkas, M.R.C.S.E., L.R.C.P.L.

[*Read before the Royal Society of N.S.W.*, 1 *November*, 1876.]

In the spring of 1874 I discovered two teeth in the shale of the Low Main Coal Seam in the Carboniferous formations of Northumberland, that were quite new to me and to all Coal Measure palæontologists to whom I submitted them, and in none of the numerous works to which I then had access were there any

figures or descriptions of fossil teeth at all similar, either in their external form or in their internal structure; the teeth that most nearly resembled them were certain varieties of *Petalodus* described and figured in Newberry and Worthen's Geological Survey of Illinois, U.S. One palæontologist whose knowledge of fossil fish teeth is second to none, submitted that they might be a variety of *Petalodus*, for in many respects their external characters agreed with those of some teeth of that genus discovered in America. So far as the outer appearances were concerned I inclined to agree with this judgment, but when I had made a microscopical examination I saw that in structure at least, these teeth differed very much from the minute anatomy of *Petalodi* teeth; I, therefore, provisionally only, named these new dental organs as pertaining to a fish of the genus *Petalodopsis*, and gave them as a specific name *mirabilis*, on account of the structure. A description of the external characters and the internal structure appeared in "The Monthly Review of Dental Surgery," for May, 1874, as one of a series of papers I was publishing therein "On the Microscopical Structure of Fossil Teeth from the Northumberland True Coal Measures."

These two teeth were discovered on separate pieces of shale, and were unaccompanied by any other remains, I, therefore, in the above paper, hinted that *Petalodopsis* was probably a Selachian; I also mentioned, however, that one of the features of the internal structure was unlike any structure that I had seen in the teeth of any fossil fishes, labyrinthodonts, reptiles, or mammals, while the rest of the characters of the minute anatomy closely resembled those of the mandibular and palatal teeth of *Ctenodus*. As I had not at that time seen *Ceratodus* nor read Dr. Günther's paper, I did not receive the hint that the latter observation might have given me, viz., that the strange teeth that I had named provisionally as *Petalodopsis mirabilis* were really the incisor or vomerine teeth of *Ctenodus*. It was reserved for Mr. T. Atthey to make this observation, which he did in the "Annals and Magazine of Natural History," for May, 1875, in a paper "On the Articular Bone and supposed Vomerine Teeth of *Ctenodus obliquus*"; he therein says—"On a thin slab of shale from Newsham (this is the pit from which I obtained my specimens) in my possession, and which measures 5 by 3¼ inches, are seen imbedded one rib, several bones of the head, fragments of scales, and what I take to be right and left vomerine teeth of *Ctenodus*." He then briefly describes the teeth, and closes his remarks by stating that "the microscopic structure of these teeth corresponds exactly with that of the maxillary teeth of *Ctenodus*. I possess about a dozen other specimens believed to be vomerine teeth of *Ctenodus*, in close proximity on the same slabs to the bones of the head and teeth of *Ctenodus*." Mr. Atthey's

statement concerning the structure, we will see hereafter, is not altogether correct. Accompanying the above-quoted paper were illustrations of the vomerine teeth, which do not differ from those I had figured a year previously. Mr. Atthey does not state why he supposes these teeth to belong to *Ctenodus* but he leaves it to be inferred that his belief is founded upon discovering them often accompanied with undoubted remains of *Ctenodus*, nor has any other proof than this been yet obtained; still, knowing as we do that *Ctenodus* is similar in its details to *Ceratodus*, we are justified in supposing that it also possessed vomerine teeth. *Ctenodus* is also very closely allied to *Dipterus*, and Dr. Günther considers that he has evidence to show that the latter fish possessed vomerine teeth, for he has found a head with fang cavities situated just where the incisor teeth should have been; the vomerine teeth of *Dipterus*, however, have never been discovered. Should this statement of Dr. Günther be correct, it is rendered more probable that *Ctenodus* was armed with similar oral appendages. To the facts that these petaloid-shaped teeth are found associated with remains of *Ctenodus*, that the allied fishes *Ceratodus* and *Dipterus* have vomerine teeth, we must add that they have a certain degree of resemblance in form to the known incisor teeth of *Ceratodus* which are thus described by Dr. A. Günther:—"The vomerine teeth are broad and rather low laminæ with a convex and trenchant margin, the outer or posterior part of which slightly serrated. Each lamina is 13 millims long, and in the middle 5 millims deep. They are inserted in an oblique direction to the longitudinal axis of the vomer, and meet in the middle at a right angle; being implanted in cartilage, they are slightly movable."

A vomerine tooth of *Ctenodus* "presents some rather peculiar characteristics; it is 2-5ths of an inch in height, about the same dimensions from side to side at the broadest part, which is near the superior border, and 3-10ths of an inch in thickness at the lower portion of the base. The tooth presents two portions, a crown and a base, which are only distinctly separated on the posterior surface; I shall not, therefore, describe them separately, but take the tooth as a whole. The posterior surface (Fig. XIV) is somewhat triangular in shape, with the apex pointing downwards; it is concave from above downwards, the concavity being most pronounced near the lower border of the tooth, where the apex of the triangle is bent backwards rather abruptly; the upper portion of this surface is smooth, shining, and minutely pitted; the lower is irregularly pitted, the depressions being comparatively large, the raised portions round the pits give this part of the surface a coarsely reticulated as well as pitted appearance. The anterior surface (Fig. XVI) is divided into a crown and a base; the crown is convex from above downwards

and slightly so from side to side, the vertical convexity being most marked where the crown rises from the base; the surface is smooth, shining, and covered with minute pores; the base is concave vertically and convex from side to side; it is rough, from the large punctations and the coarse reticulation; this surface of the base is triangular, and the apex is pointed downwards and curved forwards, giving the base, in a side view, the appearance of a heel (Fig. XV) or process protruded from the back of the tooth proper, as in the teeth of Janassa, but in this case a bony mass unites the anterior and posterior points and makes the whole a solid osseous base. The superior border is convex from side to side, and ends at one extremity very suddenly as though a portion had been broken away, which is not the case, this being a genuine character of the tooth; there are five denticles on this margin, those on the most rounded portion being the best defined; the denticles resemble broad, flattened tubercles, with a smooth and shining surface.

"In the base the vascular canals are very numerous, and run apparently at right angles to the vertical axis of the tooth; those near the inferior border are larger than those near the junction of the base with the crown, the decrease in size being gradual, the variation in diameter being from $\frac{1}{100}$th to $\frac{1}{800}$th of an inch; the canals at the inferior border are patent, and at the superior border are continuous with those of the crown; those that extend to the external surfaces remain open, not being closed in by dentine or ganoine. Branching occurs freely, the branches being given off apparently at all angles; a vertical section of the base has, therefore, somewhat of a reticulated appearance (Fig. XVIII). The tissue between the vascular canals is homogeneous, and is not arranged around them in concentric layers; the proportion of tissue to the sum of the diameters of the canals is nearly equal, that is, the tissue situated between two canals is on an average about equal to the diameter of one of the canals. From all the medullary canals spring numerous calcigerous tubules, which branch and inosculate very freely; the branches arising from the same trunk anastomosing with each other and with the branches from neighbouring systems; besides this frequent anastomosis the branches are freely interlaced one with the other, so that it is difficult to examine their arrangement, and it renders the tissue of the interspaces dark and cloudy; the course of those that can be examined satisfactorily is observed to be short and wavy. The average diameter of the tubules at their origins is about $\frac{1}{8000}$th of an inch.

"In the crown the canals are still numerous, and though they are continuous with those in the base, they have undergone certain marked changes in their course, &c., the change occurring

at the junction of the base with the crown; their course is now directly parallel to the vertical axis of the tooth, and they are almost parallel to each other; branching still occurs, but not so frequently as in the base, and the branches are given off at a more acute angle. This arrangement of the canals gives the crown the appearance of being composed of a series of upright tubes (Fig. XVII) when a vertical section is examined under a low power. The canals are smaller in diameter than those in the base and also more uniform in size throughout their course, the average diameter being $\frac{1}{800}$th of an inch. They are open on all the external surfaces, this giving rise to the pitted appearance thereon. The tissue between the canals is homogeneous and not laminated, and they are in about equal proportions. From all the canals arise calcigerous tubules, which are short and run a straight course; they branch frequently, and the terminal branches anastomose with those from the nearest vascular canals. The intermediate branches inosculate with others given off by the same trunk or with those arising from neighbouring tubules, but which spring from the same canal. They measure at their origin about $\frac{1}{8000}$th of an inch in diameter and the minute branches average about $\frac{1}{30000}$th of an inch, but the extreme terminal branches can only be observed under a power of 600 diameters; they have, therefore, an exceedingly small, almost immeasurable, diameter. Fig. XIX gives an excellent illustration of the method of branching pursued by these tubules." I may observe that this arrangement is totally different from that of any tooth structure that I have investigated under the microscope, whether fossil or otherwise. "The tubules arise by a comparatively large trunk, which immediately gives off from all sides a number of short fine tubules, some of which are larger and longer than the others. These larger branches in their turn give off minute branches in the same manner as the parent stem; the trunk of the tubule after proceeding a short distance divides into two main branches, which give off two sets of tubules like the main portion of the tubule. This process of double division goes on until anastomosis takes place with the terminal branches of a tubule from a neighbouring canal. Each tubule and its main branches divide dichotomously. Although the figure I have exhibited shows the peculiar structure very fairly, it requires at least 600 diameters to do so perfectly, and even under that high power it requires a trained eye to detect the minute branches dividing once again. I cannot better express in words the peculiar method of branching of the tubules and the main branches than by remarking that they are 'feathered.'"

Such is the account I gave of a vomerine tooth of *Ctenodus* in my papers to the "Monthly Review of Dental Surgery" for May and June, 1874; but at that time I considered it to be a

new tooth, which I provisionally named *Petalodopsis*. Through the kindness of Mr. W. Macleay, who supplied me with two vomerine and two palatal teeth, I have had the opportunity of examining the structure of the vomerine teeth of *Ceratodus* under the microscope. I made a vertical section, and was pleased to find that the fundamental structure was similar to that which I have just described. Still there are marked points of difference, for in *Ceratodus* the tissue is greater in quantity than the sum of the diameters of the canals, and the calcigerous tubules are not feathered, but they do branch as we observed the tubules in the palatal and mandibular teeth of *Ctenodus* to do. Externally also the incisor teeth of *Ctenodus* and *Ceratodus* are essentially similar, both being evidently constructed to answer the same purpose. In minutiæ, however, there are differences by which one could easily distinguish the one from the other.

Judging from the anatomical, microscopical, and palæontological evidence before us, we can have little doubt concerning the teeth I have just described. They pertain to *Ctenodus*, and so far as we have progressed in the descriptions of the different parts of *Ctenodus* the evidence is strengthened that *Ctenodus* is closely allied to *Ceratodus*.

Part IV.

ON THE DENTARY, ARTICULAR, AND PTERYGO-PALATINE BONES OF CTENODUS.

By W. J. Barkas, M.R.C.S.E., L.R.C.P.L.

[*Read before the Royal Society of N.S.W.*, 1 *November*, 1876.]

We have now to leave those characters of this fish that are strictly dental, and enter upon the description of the different parts of its osseous structure, or rather, of those parts of it that are known to us, for a portion of the endo-skeleton has yet to be discovered, and necessarily many parts will not have been capable of fossilization. In the previous portions of this series of papers I showed that, in the external characters of the teeth of *Ctenodus* and also in their structure, there were many points of resemblance to the dental features of *Ceratodus*. To-night I intend to speak of the dental bones, more especially, pointing out their osteological characters, and incidentally I shall draw attention to the dental arrangements. We will then see that even in these points the similarity is pretty closely carried out between *Ctenodus* and *Ceratodus*.

The mandible or dentary bone is comparatively frequently discovered in the shales of the True Coal Measures of Northumberland, but no jaw has been brought to light in any other formation so far as my knowledge extends, and in all cases the tooth is found still attached to it. In those cases where teeth are discovered unconnected with the mandible (a frequent occurrence) or pterygo-palatine bone, they show evident traces that they were once anchylosed to the bone, in fact, we saw when examining the teeth microscopically that the osseous structure of the bone gradually merged into the true dental tissue. Mr. Atthey, in a paper that appeared in the Trans. Northd. and Durham Nat. Hist. Socy. vol. iv, states that he has obtained the dentary bones of *Ctenodus tuberculatus*, *C. cristatus*, *C. obliquus*, *C. elegans*, *C. imbricatus*, but I myself have only had the opportunity of examining the mandibles of the first and third species named above; this want of observation is, however, of no moment, as Mr. Atthey distinctly states that the variation in form is very slight, being mostly one of degree in size. Mr. T. P. Barkas, F.G.S., records in different periodicals his discoveries of mandibles, and figures one in his book "Coal Measure Palæontology," but Mr. Atthey, in conjunction with the late Mr. Hancock, were the principal authors on the different parts of the endo-skeleton of *Ctenodus*, and as their remarks are generally exact, I shall employ their words, for my descriptions could only be similar in regard to the facts. "In *Ctenodus* (*obliquus*) the ramus is a stoutish bone, flattened vertically, with the upper margin turned over towards the external surface to give support to the large dental plate; it is therefore channelled on the outer surface and somewhat convex on the inner. The posterior extremity projects backwards beyond the dental plate a little more than half the length of the latter, and is for the greater part occupied by the glenoid surface, which extends from the upper margin, and is a deep, wide, circular notch, inclining backwards and downwards. In front the symphysial surface is straight, extending the whole depth of the ramus, and is grooved transversely. The dental plate is about two-thirds the entire length of the ramus, and is placed nearer the symphysis than the posterior extremity. The ramus is upwards of 3 inches in length, and including the thickness of the dental plate, is an inch deep." Fig. XX pourtrays the inner surface of the dentary; the dental plate resting on the upper border; the symphysis; and the glenoid notch. Fig. XXI exhibits the other surface with the dental plate overhanging. I may explain that these figures are copies of drawings published by Mr. Atthey. I am not able to give original drawings, as my specimen was destroyed on my travels. From the above description it will be seen that each mandible possesses only one tooth, but Mr. T. P. Barkas, in a letter to the "Scientific

Opinion" or the "English Mechanic," I am not now sure to which nor have I access to them to find out, but in that letter he remarks that he has evidence to show that in one case at least the mandible and maxillary bones had each two teeth; however this may be, it is the general, if not universal rule, that each of these bones carry only one tooth. Putting aside the exceptional example mentioned by Mr. T. P. Barkas, no marked difference can be observed between this mandible and the mandible or dentary bone of *Ceratodus;* the similarity is carried further, in that both these genera have the lower jaw composed of two osseous portions, an inner or dentary bone and an outer or articular bone, which in the modern fish are held together by an intervening mass of cartilage and were presumably so united in the palæozoic fish. It was only recently that the articular bone was discovered, or rather, the bone had been found some time by Mr. Atthey, but he did not recognize it until he had had the opportunity of examining the articular bone of *Ceratodus*. In 1874 he verified his belief, for he discovered two specimens of the mandibular arrangement of *C. obliquus*, in which the dentary and articular bones were in their natural positions. These articular bones I have observed in the cabinet of Mr. T. P. Barkas, and I have one in my possession. It is this specimen that I pourtray in Fig. XXII. In describing this bone, Mr. Atthey states that it varies much in length—as much as from $\frac{3}{4}$ of an inch to 4 inches; he then proceeds:—"The articular bone of *Ctenodus* is of about the same length as the inner plate or ramus which bears the teeth, slightly convex on the outer surface, and marked by five or six apertures for vessels; it is pointed upwards in front like the prow of a boat. Its posterior border presents two scallops, the upper being somewhat larger than the lower, which extends to the posteriorly projecting point of the lower border, which is convex; the upper scallop ends at a rounded projection, which separates it from the upper border. This border presents two shallow concavities, the anterior occupying the greater part of the border; the posterior has a projection on its inner side, somewhat in the form of a bracket, for the support of the teeth of the inner plate or ramus." In the bone that I figure there are some slight points of difference from the above description, the inferior margin is not so curved anteriorly; the upper concavity on the posterior border is not so large as the lower one, nor does the superior margin present two concavities. With these minor exceptions, however, my specimen agrees with his account.

The pterygo-palatine bone (Fig. XXIII.) is a flat bone, situated along the front and sides of the roof of the mouth, having its antero-posterior diameter much greater than its lateral diameter; its posterior extremity is much more expanded than its anterior.

The anterior extremity is bluntly pointed and projects beyond the general body of the bone; from this process the outer border runs in a direction outwards and backwards and joins the posterior margin in a rounded point; this border is very irregular in outline from its alternate concave and convex curves, the bends themselves varying much in their degree. The posterior border presents two gentle concavities, which join a little to the inner side of the centre of the margin. The inner border presents anteriorly a surface for union with the similar portion of the opposing bone; behind this it forms a broad sweeping concavity outwards and backwards, and then a slight convexity just before its junction with the posterior border. The under surface bears upon its outer and anterior portion the dental plate; which plate projects somewhat beyond the bone, more especially at its posterior extremity. When the two pterygo-palatine bones are in position they are united anteriorly by a long suture, they then diverge widely in their progress backwards. In all these points this bone corresponds closely to the pterygo-palatine bone of *Ceratodus*, with the exception that the latter is hardly so expanded posteriorly. The peculiarity of this bone (and also that of *Ceratodus*) is that it occupies the position of two bones, the palatal and inner pterygoid, and it presents greatly the form that would accrue on the union of these two bones as they are observed in the fossil fish *Dipterus*. I may remark in passing, that *Dipterus* possesses many characters in common with *Ctenodus* and *Ceratodus*, more particularly as regards its teeth; but in the formation of its upper jaw there are, as I have remarked, two distinct bones which are united by a suture. The form of this bone in *Ctenodus* and *Ceratodus*, and the fact of the similarity that it has to the united palatine and pterygoid bones of *Dipterus*, conclusively prove that Dr. Günther was right in his conjecture that these two bones have been merged into one in the case of *Ceratodus*, and, as Mr. Atthey first pointed out, in the case of *Ctenodus*.

As I have not a pterygo-palatine bone with me at present, I have had to trespass again upon the drawings of my friend, Mr. Atthey. The engraving appeared in vol. iv of the Transactions of the Northumberland and Durham Natural History Society.

[Plates.]

Fig I

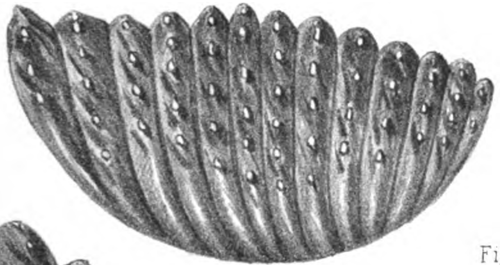


Fig II

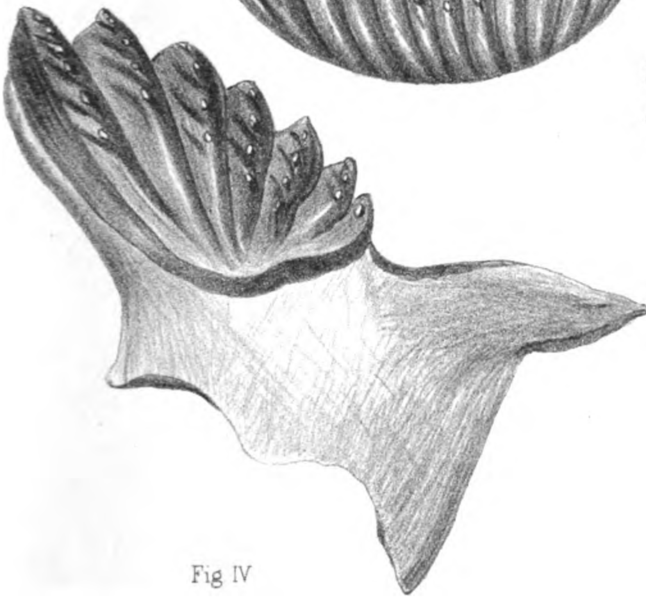


Fig III

Fig IV

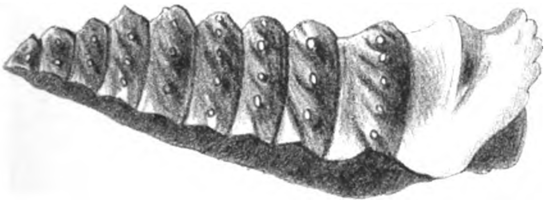


Fig V

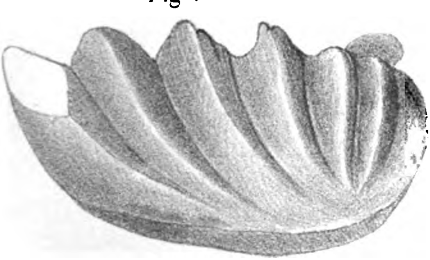


Fig VI

S T Leigh & Cº Lith

I Ctenodus tuberculatus. Nat. size
II C. obliquus " "
III C. elegans " "

IV C concavus Nat size
V C monocerus " "
VI C imbricatus " "

Fig VII

Fig VIII

Fig. IX

Fig. IXa

Fig. XII

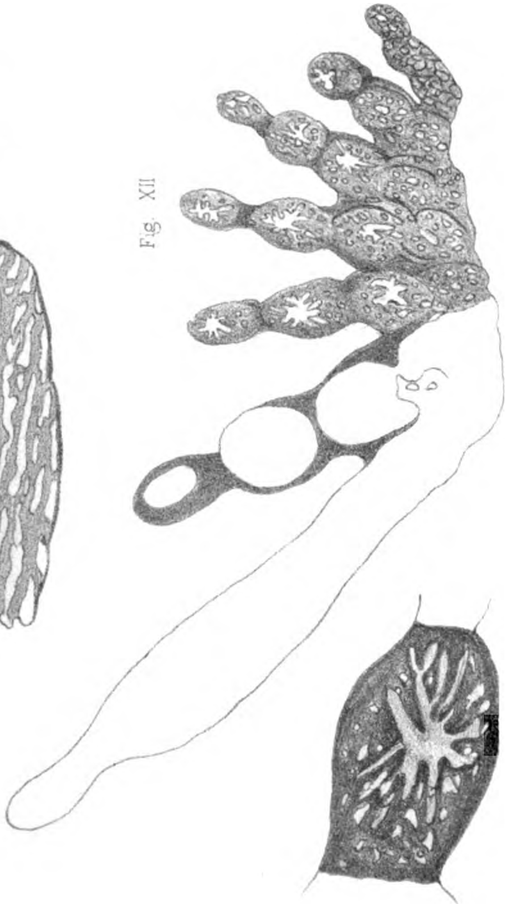


Fig. X

Fig. XI

Fig. XIII

STEUCH & Co lith.

C quadratus Nat. size.
C ovatus " "
C candatus " "

X. Vertical section of a tubercle of C. tuberculatus Magn 20 diar
XI. Medullary canal of C tuberculatus, vert sect. Magn 250 diam
XII C. elegans Trans. sect. of tooth Magn 20 diams

Fig. XIV

Fig. XV

Fig. XVI

Fig. XVII

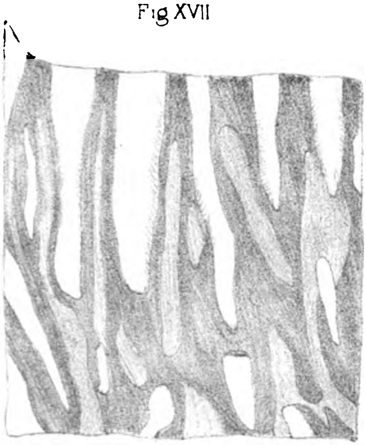
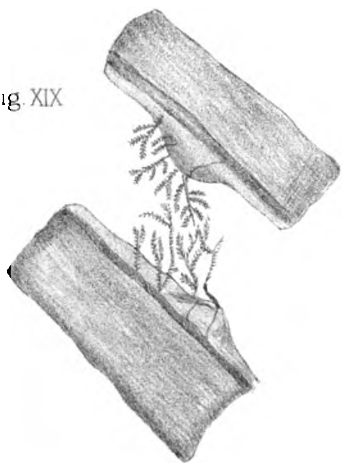


Fig. XVIII

Fig. XIX



XIV Incisor tooth of Ctenodus Posterior view XVII. " " vert sect. of crown Magnified
XV " " " side " XVIII. " . " " base "
XVI. " " " anterior " XIX. " " " " crown " 600 diam:

Fig. XX

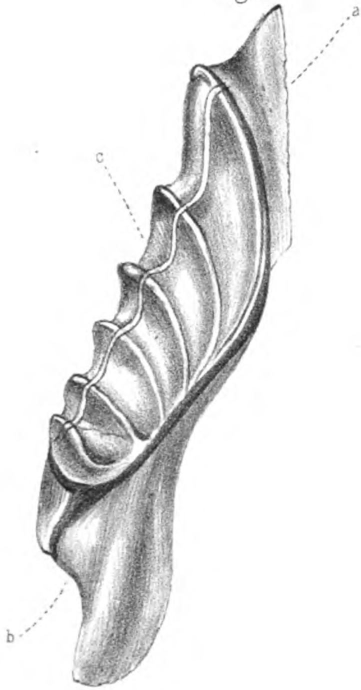
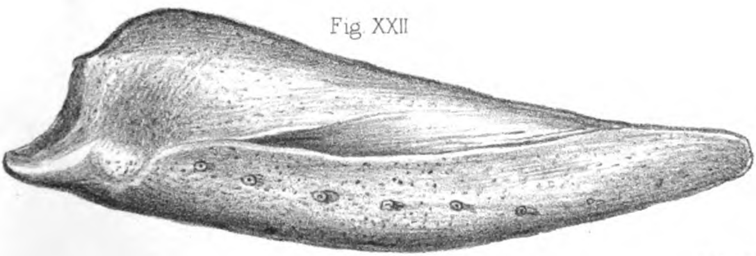


Fig. XXI

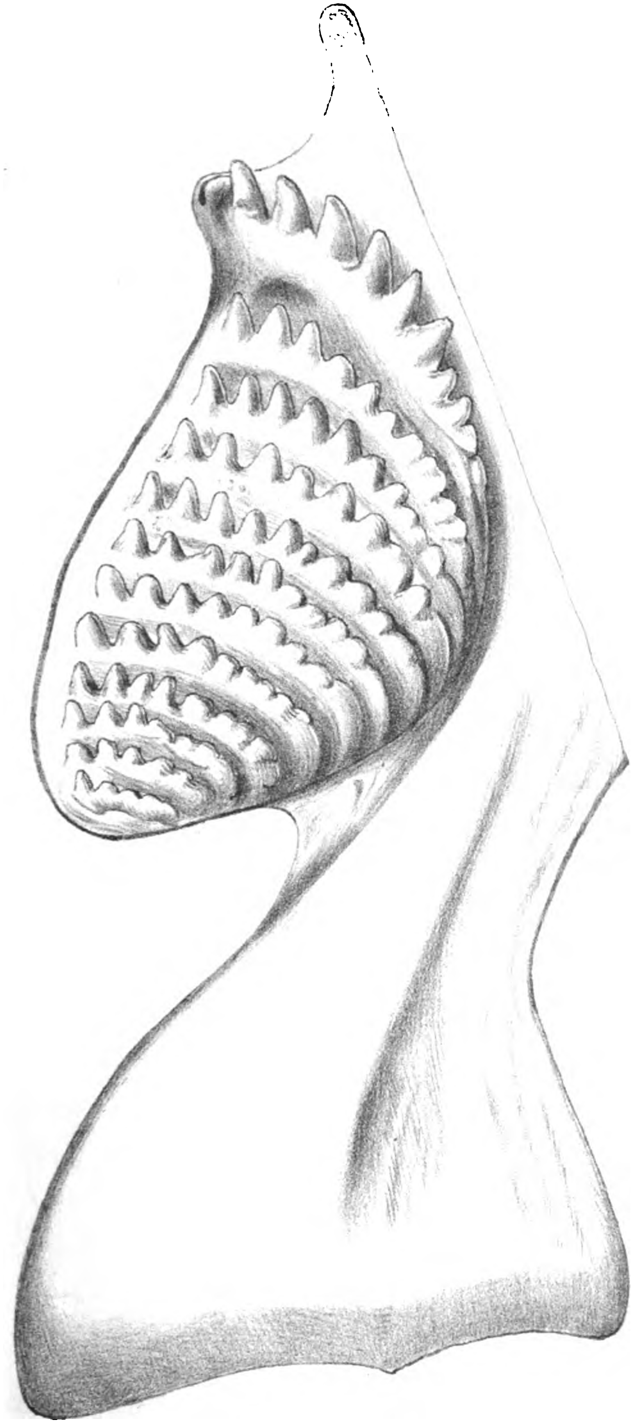
Fig. XXII



S.T. LEIGH & C° LITH.

XX. Mandible of Ctenodus. imbricatus Inner surface. Nat. size.
XXI. " C. obliquus outer surface " "
XXII. Articular bone of Ctenodus. Nat size.

Fig XXIII



XXIII. Pterygopalatine bone of Ctenodus tuberculatus. Nat. size.

ON THE FORMATION OF MOSS GOLD AND SILVER.

By Archibald Liversidge,

Professor of Geology and Mineralogy in the University of Sydney.

[*Read before the Royal Society of N.S.W., 6 September, 1876.*]

The origin and mode of occurrence of certain of the metals which are found in the free or native state, both in mineral veins and disseminated through various rocks, has for some time been a question of much interest to me; my attention, however, has hitherto been directed more particularly to the circumstances connected with the occurrence of native gold and of the minerals with which it is usually found associated; and it was while performing an experiment to ascertain, if possible, whether the gold which was known to be present in a certain specimen of mispickel, existed in the crystallized state, or was merely disseminated through the mineral in amorphous particles, that I first obtained the peculiar form of gold which I now have the pleasure to exhibit to the Society.

I have called this remarkable, and to myself hitherto unknown artificial form of the metal "moss gold," because in many respects it resembles the well-known "moss copper," hence it is convenient to use the above term for it; although it should be stated that none of the specimens of gold presented anything like so *velvety* an appearance as that commonly exhibited by moss copper.

One of the two specimens before me was a rich piece of mispickel from the Uncle Tom Mine, near Orange, I believe, and the other a somewhat richer specimen from Paxton's, or the Rampant Lion Mine, Hawkins' Hill, obtained from a depth of 200 feet. Both contained some visible gold, the first only a few small specks, but the second was fairly rich in free gold, although the amount was not to be compared to that which it now shows. Mispickel, I may remark, is a compound of arsenic, sulphur, and iron, combined in the following proportions,—

Iron	=	34·4
Sulphur	=	19·6 (or $FeAs_2 FeS_2$)
Arsenic	=	46·0
		100·00

The first specimen was roasted in a muffle in order to expel the sulphur and arsenic, and my intention then was to dissolve

out the oxide of iron and to examine the residual gold for crystals or any trace of crystalline structure which might be present, as I hoped by the above means to set the gold so completely free from the matrix that I could at once ascertain whether it existed in the mispickel in a crystallized form or only in irregular or amorphous lumps and particles.

On taking the specimen out of the muffle after the whole of the arsenic and sulphur had been driven off, I found that the surface was studded with small, irregular, more or less rounded excrescences of gold, having much the appearance and colour of small drops of sulphur. On closer examination, and especially with the aid of the microscope, the surfaces of these mushroom-like growths were seen to be covered with minute capillary wires and branching forms, which in some cases appeared to be made up of minute irregularly-formed crystals. This is more noticeable in the second specimen. Some of the cavities in the gold are seen to be lined with the most beautiful little spiculæ of gold, and some of the rounded bosses are composed solely of such spiculæ, interlaced into a ball-like form. Many of these capillary wires are curled into most symmetrical and beautiful spirals; one about $\frac{1}{4}$ to $\frac{1}{3}$ inch in length and of about $\frac{1}{100}$ inch in diameter is coiled with the utmost regularity, the pitch of the screw being maintained uniform throughout its entire length.

In some cases the mushroom-like growths are seen to be supported on but a very slender stem, while others have apparently become recumbent from their weight and have grown along the surface.

It is by no means an uncommon thing to find natural gold in the form of capillary threads, which are often interlaced and twisted into beautiful and fantastic shapes; also as thin flakes and scales, having a more or less fibrous surface; and at times in scales so exceedingly thin that they are not thicker than ordinary gold-leaf. Some of the gold from Oura, near Wagga Wagga, occurs in this manner. The best known Australian locality for filiform gold is, perhaps, the Upper Cape River, Queensland.

I should mention, however, that I have never seen or heard of any native gold presenting exactly the same kind of appearance as the before-described artificially-formed specimens, but certainly the latter is at times somewhat similar.

Origin of the Moss Gold.

The general appearance of these peculiar cauliflower-like excrescences of gold would at first sight tend to give one the impression that they had been formed in somewhat the same way as the blebs and excrescences often observed on coke, which are so familiar to us in a fire made of so-called bituminous coal—*i.e.*, caking coal, in which constantly we see portions of the coal fuse

and swell up into fantastic blebs and bladders until the imprisoned gas breaks through the thin skin and inflames with a brilliant light. After the more combustible portions have been volatilized and consumed, a hard, clinkery, and more or less cauliflower-like excrescence is left.

But I do not think that we can account for the form of these cauliflower masses of gold in a similar way, for the mispickel shows no traces of having undergone fusion, neither does the gold; the crystals of mispickel, which by the operation of roasting have become converted into oxide of iron, still retain their original form, even down to the jagged points along the sharp splintery edges of fractured surfaces. Hence it cannot be urged that the gold had merely been left in the form assumed by the fused mispickel in the same way that a cauliflower mass or capillary thread of coke is left by the escaping gas from a piece of fused coal.

Neither can the gold have been merely squeezed out through pores in the matrix by mechanical pressure in the same way that clay is forced through moulds in the manufacture of earthenware drainage pipes, for the enclosing matrix of mispickel during the operation of roasting becomes comparatively soft and tender. Hence it could not well offer sufficient resistance to the expansion of the gold to act as a wire draw plate, even if we suppose that the gold existed in the form of small pockets of metal, and that there are the necessary minute apertures and perforations in the mispickel through which the expanding gold could make its escape.

And again, the forms exhibited by the gold show that it has not been in a fused condition, neither does it appear even to have been of a pasty consistency.

To ascertain whether this remarkable form of gold was furnished by artificial mixtures of the metal and mispickel, or was solely confined to those occurring in nature, a series of experiments was commenced, and the results obtained satisfactorily showed that the same phenomena were presented by certain of the artificial mixtures employed.

Experiment.—80 grammes of powdered mispickel were fused under a film of borax with one gramme of precipitated gold. The whole of the gold was apparently taken up by the mispickel, for no metallic particles or shot could be detected in the fused mass of regulus. The button of regulus was then roasted at a low red heat in the muffle; it fused, but after the whole of the arsenic and sulphur had been driven off, the oxide of iron was found to be more or less covered with a brown, non-metallic looking cauliflower-shaped mass of gold. On scraping it with the point of a knife the unmistakeable yellow metallic streak of gold was at once exhibited.

Moss Silver.

Next a series of experiments was made in order to ascertain whether any light would be thrown upon the subject by the behaviour of silver compounds under somewhat similar conditions.

The first experiment was the reduction of silver chloride, in a bulb tube, by the passage of a current of pure dry hydrogen, mentioned by Dr. Percy, F.R.S., in his great work on "*Metallurgy*," and by other writers.

The silver chloride was allowed to fuse, but the temperature was kept very much below the fusing point of silver, so much so that the glass was not even softened.

The surface of the reduced metal was somewhat mammilated and cavernous, and it was found in certain places to be covered with minute capillary threads and spiculæ of silver; the cavities also were more or less filled with them.

Some silver sulphide was prepared in the humid way from silver nitrate. This was well washed, dried, and transferred to a French crucible, and then fused under a layer of borax in an ordinary melting furnace.

The mass of sulphide, weighing about 2 ozs., was then cut in two by means of a large knife and hammer, and one of the two parts roasted in a muffle furnace. The piece of silver sulphide was placed on a small scorifier just inside the mouth of the muffle, where for some time the temperature did not exceed the melting point of tin (*i.e.* about 442° F.) Within a very few minutes (between 10 and 15 minutes) after the lump of silver sulphide had been placed in the muffle, beautiful little growths of metallic silver were seen to be dotted over its surface, and particularly near the upper edges; the lower portion of the mass, to a height of about ¼ inch only presenting one or two points of silver at the right-hand end. This experiment was repeated several times with fresh pieces of the silver sulphide.

The projecting filaments had a most brilliant silver-white colour and lustre.

Their surfaces are strongly striated parallel to the length of the filament, and the larger ones are in most cases more or less curved or spirally convoluted. Towards the base the majority become much thicker, and in one direction they are usually much broader than in the other, hence they in this respect somewhat resemble blades of grass.

In certain instances the crystals could almost be seen to lengthen—a perceptible increase in length in more than one instance was observed within the space of between one and two minutes.

The crystals seem to increase in length and thickness far more rapidly during the first hour than afterwards, and their growth does not appear to be materially hastened by urging the tem-

perature—that between the melting points of tin and zinc (770° F.) appeared to be the most favourable. At a higher temperature the whole surface of the silver sulphide becomes covered equally with a coat of metallic silver.

The extrusion of the silver crystals cannot well be caused by pressure from without inward, for neither the silver nor the silver sulphide undergo fusion or even softening; neither can the production of the filaments be due to the simple and ordinary process of reduction by the removal of the sulphur as sulphurous acid gas, otherwise the whole surface of the mass of heated and more or less roasted sulphide should be covered with a coat of reduced metallic silver, just as when the sulphide is reduced in a current of hydrogen gas. But such is not the case; the extruded wires and filaments appear to be rooted in the sulphide, as if they pushed their way out from within, and they usually project out at nearly right angles to the surface of the apparently unchanged dark lead-coloured silver sulphide, just as Dr. Percy describes the formation of silver filaments, from the same compound under the reducing agency of a current of hydrogen gas.

It may be that their formation may have been determined by the presence of nuclei of some sort, just as in the case of various saline solutions.

On even the most searching examination I cannot detect any difference between the filamentous silver thus artificially formed and specimens of similar native silver.

Since making my experiments, I find that De la Beche says, in his "Geological Observer," p. 768:—

"Artificial sulphuret of silver was found to be readily decomposed by steam, and more easily so at a moderate heat. At a temperature under the melting point of zinc this was soon effected, and the silver effloresced in such forms as to induce Mr. Gustav Bischoff to regard the moss-like and filamentous occurrence of native silver in veins as very probably the result of the decomposition of sulphurets."

Moss Copper.

It is a well known fact that metallic copper occurs diffused through certain kinds of copper regulus, in the form of minute angular particles, which do not show the least trace of having undergone fusion; all the edges of these particles are sharp and not in the least rounded, and where cavities occur the metallic copper may be seen protruding into them in the form of minute points and hair-like threads or filaments.

Dr. Percy, in speaking of *moss copper* says*:—"In copper works this term is commonly used to designate those accumula-

* Percy's "Metallurgy," vol. i., p. 359.

tions of filamentous or moss-like copper, which are formed in cavities in pigs of certain kinds of regulus. Mr. Edward informs me that, in making copper from Cornish ores, moss copper seldom appears, but more of it is produced when these ores are melted in admixture with a little Irish ore (copper pyrites mixed with *much iron pyrites)* : it occurs most abundantly when foreign ores are much used. It is chiefly observed, and in the finest state, in *pimple metal*, when all the cavities are filled with it, and it is found protruding from the bottom of the pigs into the sand underneath; sometimes a little of it, strong and wiry to the touch, appears on the upper surface of the pigs. According to Mr. Edward, it may be seen in the little prills or shots of *metal* in the ore slag; and the surface of the pigs of metal from the *calcined metal* furnaces are covered with a coating of it, generally of a dark colour, and as thick as the nap or pile on velvet.

"In specimens in my collection the filaments of copper vary in size from the finest thread to fibres $\frac{3}{16}$ of an inch in diameter, and from one of three specimens obtained from a *fine-metal* furnace bottom I have taken separate filaments perfectly continuous, and exceeding 5 inches in length.

"Under the microscope the filaments present numerous minute parallel and longitudinal lines or grooves, as though they consisted of bundles of extremely delicate fibres. * * * * * * *

"The mode in which these fibres are produced is an interesting subject of inquiry. Each fibre seems to have been pushed, as it were, through a draw-plate, and at a temperature when the metal was soft, but certainly not exceeding that of well-melted copper, for otherwise the fibres immediately after their protrusion would have been remelted into globules." Then he goes on to mention that "filaments of silver, which, examined under the microscope, appear to possess *identically the same structure* as those of moss copper, may be formed by heating finely-divided sulphide of silver in a current of hydrogen at a temperature sufficient to agglutinate the sulphide, but below the actual melting point of silver. This beautiful experiment may be made in a glass tube, through which a current of the gas is passed. Long delicate fibres of silver may be seen protruding from minute rounded masses of the sulphide; and as they are produced while these masses are in a soft state, and lying free in the tube, the idea that they result from the application of external mechanical pressure in a similar manner to maccaroni, can hardly be entertained.

"There seems to be a force in operation at the base of each filament, which causes the particles of silver at the moment of liberation successively to arrange themselves in one continuous fibre or series of fibres; or, in other words, each filament grows, as it were, from a root imbedded in sulphide of silver."

Experiment.—I placed some lumps of native copper disulphide (*Redruthite*) in a hard-glass bulb tube, heated and passed current of hydrogen gas. After the experiment the whole surface of the mineral was found to be thickly covered with a nap of acicular filaments of copper. No traces of fusion were exhibited.

Dr. Percy also shows by a series of experiments that metallic copper is separated in a similar way by simply fusing some copper disulphide (Cu_2S.) in a crucible. And he further states that there is at present no certain knowledge of the cause which brings this about.

The foregoing results obtained by different eminent scientific observers, together with those yielded by my own experiments, afford, I think, some very interesting information, much important matter for reflection, and a large field for future experiment.

The conditions under which the formation of crystals have been observed may be briefly stated to be comprised by the following divisions; *i.e.*, crystallization takes place under the following conditions:—

Methods by which crystallization may be produced.

1. By condensation from a state of vapour.
2. From solution.
3. From a state of fusion.
4. By electrolysis.
5. By "spontaneous" change.
6. By thermo-reduction.

1. *Condensation* of a substance from a state of vapour—*e.g.*, iodine, arsenic, water vapour yielding snow and hoar-frost.

2. *Crystallization from solution.*—As when crystals of a salt are obtained by the evaporation of its solvent; and as when a solution of sulphur in carbon disulphide is allowed to evaporate spontaneously, beautiful crystals of sulphur are left.

3. *On solidification from a state of fusion.* This is commonly seen when metals such as bismuth, antimony, and others are allowed to solidify slowly. Beautifully crystallized examples of such metals and of sulphur may be readily obtained in the following way:—Melt a considerable quantity of the substance in a crucible or ladle, and when a thin coat has formed over the surface by cooling, pierce the crust and pour out the still fluid contents as quickly as possible. A large part of the metal or sulphur, as the case may be, will be left lining the inside of the crucible in the form of most beautiful groups of crystals with sharply defined edges and angles, and not as the rounded imperfect semifused-looking bodies that we might naturally expect when we consider the density and viscosity of the fluid in which they were formed and by which they were bathed.

4. *Crystallization by Electrolysis.* When solutions of the salts of the heavier metals are submitted to the action of electric currents, they undergo decomposition, and the metal which is deposited at the negative pole is usually more or less crystallized. A current of low intensity, *cæteris paribus*, seems to favour the formation of well-developed crystals. The reduction of a metallic solution by a more electro-positive element may probably be classed under this head, as stannic chloride by zinc, or silver nitrate by lead, and so on.

5. *Spontaneous Crystallization*, as it is usually termed, *e.g.*, the gradual passage of amorphous plastic sulphur into the crystalline state, also the similar change undergone by barley sugar. Many well known chemical precipitates apparently undergo spontaneously a similar change. Again, the gradual conversion of tough fibrous wrought iron into hard brittle iron with short grain, by repeated concussion and vibration, seems to be a variety of crystallization; certainly a great molecular change has taken place—but this matter requires further investigation. Then we have the passage of blocks of tin, which had been exposed to intense cold, from the malleable and non-crystalline to a fibro-crystalline and brittle state,—in fact, so brittle does the tin become that it more or less completely falls to powder.

The devitrification of glass may also be here mentioned.

6. *Crystallization by thermo-reduction.* I think that we may safely regard the forms exhibited by the artificially produced moss metals as varieties of crystalline forms, and with as much reason as the mineralogist assigns a place for the similar natural forms amongst crystals; the arborescent and other group forms assumed by native metals can be traced from normal and primary forms, such as of the octohedron and rhombic dodekahedron through various degrees of elongation and attenuation until we arrive at the filiform and capillary threads, a number of which aggregated together give in the velvet or plush-like mass of moss copper or other metal. Moreover, some portions of the gold reduced from the mispickle showed branching and arborescent groups which had all the appearance of elongated dodekahedra placed end to end in no way differing from natural specimens except in minuteness and perhaps greater brilliancy of lustre.

But these crystals have been produced by a process differing considerably from the methods enumerated in the first five divisions; hence the necessity for forming the sixth and last group.

The artificially prepared moss metals are produced by a process of reduction, aided neither by vaporization, solution, fusion, or electrolysis, neither are they produced "spontaneously," but they are prepared by the aid of a heated re-agent. Hence I have for convenience ventured to form a special class, *i.e.*, *crystallization by thermo-reduction.*

This matter is, of course, very closely connected with the ordinary metallurgical processes of reduction, but in such manufacturing operations no effort is made to obtain the metal in the crystallized state; on the contrary, it is the practice to favour the conversion of the metal into the liquid state as speedily as possible.

Although, perhaps, there may be no true analogy between the two cases, still it would be very interesting to calculate the amount of force requisite to produce the crystals, supposing that they had been mechanically pulled out like wires through a draw plate, or had been squeezed out through moulds similar to lead tubing.

I hope at some future date to be in a position to supplement the foregoing preliminary notes upon a question which is of great interest and importance in the chemical geology of mineral veins and deposits, when the series of experiments at present in hand are somewhat nearer completion.

Discussion.

The Chairman said he could have brought some specimens of quartz in which the gold was exactly in the form of wire. In one case this wire was in the form of a true lover's knot. He was sure what they had heard to-night would lead to the explanation of some very curious phenomena. It had been said that volcanic heat melted gold from some previous condition. Now we know that some of our volcanic rocks could not have been at a great heat. In Victoria volcanic rocks lie upon vegetable matter, which has been only dried, not carbonized. If the quartz had been melted, the gold would have been all evaporated. It had been found that gold was lost in the Mint, and they wondered what had become of it. They swept the roof and the chimneys and found it there. So in certain lead works there had been accomplished a saving of £10,000 a year, by building long chimneys curved and extending backwards and forwards over some miles length, in which they collected the lead fume which had evaporated. This crystallization at a low temperature would explain many things. It remained a mystery how gold could be twisted and tied into a knot in the solid quartz where it was found.

Mr. H. C. Russell said he hoped Professor Liversidge would be able to find out how these forms occurred. Crystals form out of very complex fluids. Each substance seems to have the power of taking to itself in crystallization those particles which belong to it, and rejecting those that do not. What we want to know is: *how* does the force of crystallization act? We know it was one of the forces active in forming meteorites from the primitive matter, which, according to the theory of La Place, once existed in the form of gas. And if the investigation which

Professor Liversidge is now carrying on shows us *how* crystals are formed on the earth, it will be one step forward in the investigation into the mysteries of nature.

Mr. Dixon, F.C.S., asked whether the silver was melted during the reduction. Did not the air raise the temperature of portion by the combustion of the sulphur; and would not that be sufficient to melt the silver?

Professor Liversidge said that the silver presented no trace of fusion. The temperature was ascertained by placing a piece of zinc and tin or cadmium close to the spot on which the sulphide of silver was; so that the two were kept at the same temperature. He did not think the increasing growth of the metal was due to the combustion of the combined sulphur. The crystals increased at a much greater rate in length and breadth than in thickness. The sulphide was reduced to a metallic state at a heat just about that of melting tin. The reduction did not take place regularly. These silver growths started out from particular points, and increased in size. It was not a case of mere reduction. If it were, they would get the whole surface of sulphide of silver equally reduced. The reduction seems to take place capriciously, as if the point were determined by some nucleus; fibres of silver stood out from the unreduced surface of the sulphide. One could almost see the fibres grow. There was a great change in a minute. It was generally supposed that the deposits of native metal could only have been formed by electric current or by the agency of great heat, perhaps assisted by the vapour of water. By these experiments it was shown that they could get metals in forms not distinguishable from the natural ones. He had in his hand a specimen of quartz containing filiform threads of gold. In most cases the contorted crystals occur in little cavities, not in the solid quartz. With regard to volcanic rocks only drying the vegetation under them, in the district of Etna people depended for their store of ice on the snow covered and protected by ashes overlaid by lava.

Mr. W. J. Stephens, M.A., remarked that when lava was running the part next the ground was tolerably cool, while what came over it was red hot.

Professor Liversidge, in answer to a question, said it did not follow from his experiments that the crystals obtained were pure gold. Moss copper is specially pure. Certain metals might perhaps be purified by this process.

He also stated that he was not at present prepared to put forth any very definite and final theory to account for the formation of the moss metals; the above communication was intended merely as a preliminary notice of certain results already obtained from a large series of intended experiments now in hand.

RECENT COPPER-EXTRACTING PROCESSES.

By S. L. Bensusan.

[*Read before the Royal Society of N.S.W.*, 4 *October*, 1876.]

In the following paper I propose to make special reference to some of the new and improved methods known as "wet" processes for the extraction of copper from its ores.

Among the new methods which have been introduced, a variety of conditions exist, under which one or other has maintained its claims to the possession of some advantages over its competitors; in the main, however, they all aim at the extraction of the metal by processes requiring the smallest outlay in plant, &c., coupled with the minimum expenditure in chemicals and labour. Some metallurgists have sought to utilize bye products, as an auxiliary to other sources of profit; some have directed their attention to the simultaneous extraction of valuable metals sometimes associated with copper ores; a few have studied to perfect processes which are only available under certain *special conditions*, wherein the usual methods are not capable of being employed; and in cases where complicated mixtures have existed of metals, the extraction of one of which alone would not pay, many and ingenious devices have been resorted to, for utilizing and turning to profitable account portions of the constituents of the mineral which hithero have been a source of actual loss.

In the Australian Colonies the principal considerations which appear to suggest themselves, in connection with this subject, are,—the adoption of processes which do not necessitate the usual large outlay, and the utilization of such as are most available for particular districts, and to meet special conditions. One great desideratum is necessarily to make the *modus operandi* so clear and intelligible that it may be easily understood by most persons not possessed of special metallurgic knowledge. In a country like this, where the population is so scattered, and in which so much metallic treasure is known to exist, it is most desirable that a *resumé* of all that is generally known on the subject should be diffused; and while each inventor or discoverer of any new process only aims at the publication of his particular views and theories, and doubtless does much good, it is hoped

that a digest of the various plans adopted, a comparison of their merits, and an attempt to point out in which particular cases their individual excellence consists, may do much good in furthering the development of the Colony's resources.

It is sought to impress upon mineral explorers that methods are available for giving a value to mining property, without preliminary large outlay; but it is not intended to imply that, after inexpensive proof of value has been obtained, economy and profit may not be better attained by the introduction of labour-saving appliances, even at great outlay, though it is urged that the large outlay can be deferred until its justification is definitely and conclusively demonstrated.

Beginning with one of the most simple processes, and one with which most people are tolerably familiar, that known as the

SULPHURIC ACID PROCESS,

we find that in South Australia, at a mine of some reputation in times past, known as the Kapunda, the sulphuric acid process is in use for the extraction of copper from an ore containing only $\frac{5}{8}$ of 1 per cent. of metal. But the conditions here are peculiarly favourable, inasmuch as the mineral operated upon consists of a vast heap of many thousands of tons of debris, or tailings, which have already passed through the dressing machine: consisting principally of oxides and carbonates, it requires no preliminary desulphuration; while the sulphuric acid is made on the spot from iron pyrites, which exists in great abundance on the property. The ore is digested in the acid until all the copper is dissolved out, several successive portions being treated in the same liquor up to the point of saturation; it is then allowed to settle, run off clear into a large vessel containing scrap iron, when the copper is precipitated at the expense of the iron in the form of cement copper, of about 70 per cent. The quantity of iron dissolved is equal to a little less than the weight of the copper precipitated, in neutral solutions; the cement copper is sold to the smelters, and has only to be passed through the refinery, and run into ingots. The acid is no doubt heated when used, and probably kept nearly up to boiling point, by the introduction of a jet of steam, and the material kept agitated to facilitate the action of the acid. Taking 16s. as the value of one unit of metallic copper, and seeing that this material contains only $\frac{5}{8}$ of 1 per cent., or 14 lbs. of copper, in one ton of material, the gross value is only 10s., so that to yield a profit the cost of treatment, including the cost of sulphuric acid, labour, refining of the cement copper, and wear and tear of apparatus, must be less than 10s. per ton of ore treated.

Of course it is not supposed that we can readily find places in this Colony where the conditions will be precisely the same—

where the heap of debris already crushed will exist—where it shall consist of carbonates and oxides—where iron pyrites is found in abundance for the manufacture of sulphuric acid, &c.; but we can find many places where a little modification of the process may be made with profitable results—where large deposits of copper pyrites exist, containing 2 to 3 per cent. of copper, the pyrites itself serving in many cases for providing its own sulphuric acid, for the subsequent treatment of the oxidized or desulphurized ore.

THE SNOWDEN, OR LIME PROCESS,

is the next deserving of mention, on account of its simplicity and easy application in places difficult of access in the far interior, where the usual requirements of a reduction establishment and skilled labour would be difficult to obtain, and even valueless for the poor class of ores that may be treated by the process.

There are two necessary conditions to its application: 1st. That the ores, or a considerable portion of them, shall be sulphurets; and 2nd, that limestone be obtainable on the ground.

The process is as follows:—The mineral, containing copper pyrites is crushed, mixed with a small proportion (rarely exceeding 5 per cent.) of burnt lime; the lime and pyrites are then moistened and shaped by machinery into bricks, stacked, and roasted at a low red heat for a short time. The lime and pyrites undergo a double decomposition, the sulphide of copper being converted into a sulphate, and the lime into a sulphide of calcium. The bricks are then rapidly passed through a crusher into water, where the soluble sulphate of copper is at once removed; successive lots are passed into the same liquor, which becomes strongly acid; and if any oxide should have been present originally in the ore, or be formed by careless roasting, it will be dissolved out in the strongly acid liquor. After being allowed to settle, it is drawn off into another tank, and the copper is precipitated by passing hydrogen sulphide through the solution. The resulting product will contain 50 per cent of copper. The entire cost of treatment, inclusive of 10s. per ton for mining the ore, is about 20s. per ton, so that an ore of two per cent. could be worked at a very good profit, if the ore is plentiful and readily procured. The hydrogen sulphide is made from the ores themselves. Very little apparatus is wanted for conducting the process; a good bush carpenter could make the tanks of hardwood, taking care to use no metal in any part, at least inside, or at the joints; the bricks can be made by hand; the furnace for generating the hydrogen sulphide could be put up in a few days by an ordinary bricklayer working from a plan. The crushing of the ore will require some appliance, unless in the first instance it is reduced by a dolly, shod with iron, worked by a long lever, an appliance by which a few hundredweights can soon be reduced

by a strong boy. With only a moderate amount of instruction any person of average intelligence, and without any previous metallurgic knowledge, may conduct the process, even on a large scale. It derives its name from the Snowdon Mountains, where it is at present being successfully employed, and where, probably, no other known process would be available.

The Hunt and Douglas Process

is rapidly and deservedly gaining favour. It possesses several features that give it special claims to consideration. The apparatus used is simple and inexpensive; the treatment capable of being easily taught to an intelligent workman; the materials used in the extraction of the copper from its ores cost but little in the first place, and are capable of doing an indefinite amount of duty, with but little addition to supply inevitable waste; the precipitant is usually scrap iron, which, however, may be replaced with iron sponge.

In case the ore contains sulphur or arsenic, it is crushed, passed through a sieve of forty holes to the linear inch, and calcined. At the Ore Knob Mine in America the cost of the wood used in desulphurizing is found to be only one shilling for every ton of ore treated. The calcined ore is then treated with a solution of sulphate of iron and salt, of a certain strength, which experiment has found to be most effective; these are kept stirred in circular tanks, at a temperature of about 180 degrees Fahrenheit; the stirrers make about twenty-five revolutions, and the extraction of the copper occupies about eight hours. It is then allowed to settle, the clear part drawn off, and the turbid led into a settling vat. The copper is precipitated from a hot solution by scrap iron; the precipitation occupies twenty-four hours.

The rationale of the process is as follows:—Sulphate of iron and salt being dissolved and mixed together mutually decompose, forming sulphate of soda and chloride of iron; on the addition of ore containing oxide of or carbonate of copper (or the desulphurized ore), the chloride of iron reacts upon the copper, forming chloride of copper and dichloride, and precipitating the iron. In subsequently passing the solution containing these chlorides of copper over metallic iron, the copper then changes place with the iron, the former being precipitated as cement copper, and the regenerated chloride of iron solution being returned to the bath to act on successive charges of ore.

It will be seen that the cost of treatment is particularly small, but it may be added that the loss in treatment is less than half per cent., while the material employed in the extraction of the copper does duty many times. The one great source of expense, especially in situations far removed from the sea coast, is the iron used in precipitating; but in places where hematite is abundant they are commencing to make sponge iron to use

instead of scrap. The precipitation of one ton of copper takes about 13 cwt. of metallic iron, so that it is a very important item, a large proportion of the copper solution being dichloride. The bath of chloride of iron may of course be made by dissolving the metal in hydrochloric acid; the apparatus in which the operation is performed must be of wood, and no metal must be exposed to the action of the chemicals. The bath is prepared by dissolving 120 lbs. of salt, or 112 lbs. of dry chloride of calcium, with 280 lbs. of green copperas (sulphate of iron) in 100 imperial gallons of water; 200 lbs. of sea salt are then added; this quantity is capable of chlorodizing and dissolving about 90 lbs. weight of copper.

In case the ores contain gold or silver, the latter will be taken up by the copper solution, and can be recovered by digesting with metallic copper, while the gold remains in the tailings, which, being freed from copper, is in a condition admitting its easy extraction.

This process in the main is by no means new, though the original scheme of Robert Oxland has been greatly improved upon, and Messrs. Hunt and Douglas may be said to have given it a commercial value. In April, 1868, Oxland took out his patent for the extraction of copper from its ores by the use of ferric chloride, or chlorhydric acid. At home the latter was a waste product in the manufacture of salt cake, so that its use was less costly than the employment of salt. The precipitation was effected with metallic iron, and the bath was regenerated for the extraction of further quantities of copper. By the patent, however, it appears that after the first lixiviation Oxland dried the ore in a furnace, and subjected it to a second treatment, whereas Hunt and Douglas extract the copper in one operation, leaving only half per cent. in the tailings. Besides, the chemicals can be transported any distance in a solid form, which is no mean advantage, and the precious metals extracted at very small cost, while the whole of the reactions have been exhaustively studied by the inventors.

STEPHEN H. EMMENS'S PROCESS

was patented on 16th July, 1875, its object being the economical extraction of all the valuable metals, besides copper, which may be associated with the ore under treatment. It consists essentially of three stages:—

1st. Roasting with or without salt to oxidize or chloridize the ore.

2nd. Lixiviating with water acid, or brine, to wash out the soluble metals.

3rd. Precipitating the dissolved metals from solution.

In the first stage he adds fluor spar; in the second or lixiviating stage he adds salt or saltpetre, and sufficient sulphuric acid to evolve enough hydrochloric or nitric acid to dissolve any

metals not previously in a soluble condition; in the precipitating stage the liquor is passed over iron pyrites or other metallic sulphides with a view to precipitate any gold and silver present in solution, ferrous sulphate being sometimes added to facilitate such precipitation. The liquor is next passed over metallic iron, copper, or zinc (according to its composition), to precipitate other metals present, in such order as may be most convenient; and, finally, if any other metals in solution, the liquor is treated with an alkali, to precipitate them, and then concentrated, or evaporated to dryness, to recover the saline substances for use in successive operations. A jet of steam is used during the two latter stages, to accelerate the reaction. When silver is present in the ore, salt is dispensed with and saltpetre substituted, to avoid its precipitation and loss in the lixiviating stage, or sufficient salt is used to ensure a saturated solution; it being well known to metallurgists that, while any chloride in dilute solution will precipitate the silver present, a saturated solution will arrest its precipitation. If no gold or silver were present, the liquor would not have to pass over metallic sulphides.

The process appears to possess great merit and value, especially in Australia, where copper is found associated with other valuable metals, the presence of which has hitherto detracted from their value instead of adding thereto.

Claudet's Process

for the extraction of copper and the precious metals from their ores is one of the notable economic methods for the treatment of particular kinds of mineral. Hitherto it has been principally applied to the treatment of cupreous pyrites with great success, the average contents being about 4 per cent. of copper and 18 dwts. of silver. The pyrites is roasted with salt, which converts the metals into soluble chlorides; it is then put into vats and subjected to eight or nine washings to extract the copper and silver. The first three washings take out 95 per cent. of the metals; this is all that is sought to extract of the precious metals, but the remainder is returned to the vats for re-treatment.

The silver present is precipitated by iodide of potassium, as an insoluble iodide, after previous titration, to ascertain the quantity required and avoid waste; acetate of lead in solution is also added, which ensures a precipitation of the chloride and aids in collecting the silver. It is then thoroughly shaken, and allowed to stand for forty-eight hours, when the copper liquor is drawn off clear; the tanks are filled for a further operation, and finally cleaned out once a fortnight. The precipitate contains a considerable quantity of copper, which is readily washed out with dilute hydro-chloric acid. The precipitate is next decomposed by the addition of metallic zinc, which reduces the silver to the metallic

state. At this stage gold, if present, makes its first appearance, having been dissolved in the first instance with the other chlorides, precipitated by iodide of potassium, and converted into the metallic state by zinc. The precipitate then consists of silver, with a small quantity of gold, lead (about 60 per cent.), oxides of iron and zinc, and a small quantity of lime and copper; there is no iodine present, as it has combined with the zinc in solution, from which it is recovered for further use. The copper solution, which has been drawn off clear from the silver precipitating tank, is passed into another tank containing metallic iron, which precipitates it at the cost of the iron.

At the Widness works the value of the precious metals contained in the ore is only (2s. 10d.) two shillings and tenpence; they consist of half an ounce of silver and one and a half grains of gold; the total cost of extraction is 10d. per ton of ore treated, and the profit 2s. per ton, on 30,000 tons treated primarily for copper. The method was first introduced in 1871, and in the first year 16,300 tons of burnt pyrites were operated upon; the *additional* expense connected with the extraction of the precious metals was £416, while the value of the gold and silver after deduction of the cost of melting and refining was £3,232. The process has been very largely employed since. In Cornwall there are mines producing large quantities of poor ores which have hitherto been treated in the dry way, for copper only, but have been found to contain more silver than the Spanish pyrites; these have recently been treated profitably by the process. In the first part of the process sulphate of soda of great purity is obtained, and the iron of the pyrites being very free from extraneous matter is recovered in a state of very fine division, used for polishing looking-glasses, and sold in large quantities to the iron manufacturers for "fettling" their puddling furnaces.

The Mindeleff Process

is comparatively new, though the chemical theories involved are well known. The mode of applying these principles is certainly new. The inventor, a Russian metallurgist, has introduced his process into America, whence we derive details of the *modus operandi;* it consists of a new mode of applying light carburetted hydrogen as a reducing agent for oxides, sulphides, arsenides, and carbonates. The chemistry of the process has been long known, and various attempts have been made to utilize it, but hitherto without success. In California some experiments were made on copper ores, which were placed in a retort and heated to expel moisture; when sufficient heat was attained the gas was admitted under pressure, the escape pipe being adjusted to admit of the slow escape of the gases evolved. It is claimed that the process is a perfect success, the ore being thoroughly

reduced to a metallic state, subsequently to which it has to be run in a furnace and refined. It would be premature to offer here an opinion of the merits of this invention, and the mention of it is made here because the subject would be incomplete if it were ignored. Several attempts have of late years been made in Europe to reduce iron by the direct application of hydrogen, with more or less success.

The Ammonia Process

is the invention of Dr. Thomas Clarke and Mr. E. Smith, F.C.S., and specially intended for ores containing silver. If sulphides, they are roasted, to convert into oxides; usually, even after careful roasting, some of the copper and silver will remain in the form of sulphates, though the iron be completely oxidized; the rest will consist of oxides, and possibly a small quantity of metallic copper. The charge is then treated with calcic chloride, which removes all the sulphuric acid, forming calcic sulphate, while the copper and silver are converted into chlorides. At this stage ammonia is added, which forms chloride of ammonium; and this, with the free ammonia, dissolves the copper and silver, whether they exist as chlorides, oxides, subsalts, or finely divided metallic particles. The ammoniacal solution is then passed into a platinum tank, where the silver is deposited at the expense of the copper sheets in the tank, such copper being taken up in solution and recovered in a subsequent process. When all the silver is deposited, the solution is passed into a tank, a little caustic alkali added, and superheated steam admitted. The copper is precipitated as oxide, the ammonia being expelled, and recovered in condensers for subsequent use in fresh operations. At first sight it might appear that the cost of the ammonia would be considerable, but it is found that the loss is very small, nearly the whole being recovered without any additional expense; it is said to be in no way an objection to the process. The wear and tear of the platinum is infinitesimal, and the copper plates are easily renewed, while the copper dissolved is recovered. The copper plates require renewal only once in three months if fifty tons per day be worked. It is claimed that a very small amount will cover the cost of plant, while the material consumed is less costly than with any chlorinization process. In England calcic chloride is very cheap, being a waste product, but how far it would be available here remains to be ascertained. It would appear, however, that with oxides and carbonates the calcic chloride will not be required; and the same remark applies to ores *thoroughly* calcined, and containing neither sulphides nor sulphates. It is necessary that the ore be ground very fine, and that as much as possible of the sparry gangue shall be eliminated before treatment. Of course sodic chloride may be substituted

for calcic chloride. To the writer it has suggested itself that the use of any chloride *may* be dispensed with altogether, by simply passing the charge direct from the roasting furnace into water, when any sulphates that may have formed will be immediately dissolved, and after being thoroughly washed the charge would be ready for the ammonia, the solution of sulphates would be recovered in the usual way, and less ammonia would be required for the process. In fact, the larger the quantity of sulphates formed the cheaper the entire process, irrespective of the saving of chlorides in any form.

Other Processes.

In addition to the different processes above referred to, there are several others possessing a local value dependent upon certain special circumstances. One of the most notable is the process used at the Edgeley Hill works in England, where a very large body of poor ore, containing something less than two per cent. of copper, is crushed, and then treated with chlorhydric acid, to dissolve out the copper, which is precipitated with scrap iron. In this case the acid is a waste product, the ore very easily mined, the cost of the labour moderate, and iron procurable at a low rate.

The method of treating the copper schists at Mansfield is pretty generally known, but it may not be out of place to advert cursorily to it here. The ores contain from 1 to 4 per cent. of copper, existing in a bituminous schist; this schist is roasted in heaps, and after combustion being first communicated the bitumen present sustains it for a considerable time. It is then placed in a cupola blast furnace with coke. Matts and slags continually flow from the furnace, the former of which are again roasted, and again put back in the furnace. Repeated roastings convert some of the copper sulphides into sulphates, which are repeatedly lixiviated to separate the soluble sulphates. When any of the ore contains silver, it will come out with the copper; to extract it a quantity of lead is added to the black copper, and the alloy slowly heated in a furnace, when the lead will separate from the copper, and be found to contain nearly all the silver present; the proportions for effecting the liquidation are about one-fourth copper and three-fourths lead. Some lead will remain with the copper, which is subjected to a stronger heat, in a suitable apparatus, by which the whole of it is sweated out, the copper cakes remaining in a porous state, and being subsequently refined.

Remarks.

The study of the subject has convinced me that, where the extraction of the copper is the sole consideration in cases where the quality is pretty good, there is no process of reduction more

economical and more suitable than the old-fashioned smelting process. Few people, however, have the slightest idea of the difficulties that beset the owners of copper-smelting works, especially in a new country; the inefficiency of furnace-builders and smelters; the difficulty of procuring refractory clays, and making bricks that will stand; the want of sufficient knowledge of the chemistry of smelting, and the way of making suitable fluxing mixtures, the impossibility in some parts of getting coal or good wood; and, lastly, the enormous expense of erecting and maintaining a copper works. This paper is written for the use of those who have no such advantage (I mean the advantage of a well-appointed and well-officered smelting works, with plenty of work to keep it going, and other favourable conditions); and most particularly addressed to those who possess large bodies of ore, too poor to pay by the ordinary smelting process, or possessing some element of value that could not be rendered available by that process.

To have given this subject a proper value it would have been well to have endeavoured as far as possible to show the cost of applying each of the processes described. Such was my original intention, but several difficulties presented themselves, the principal of which was that in almost every case the materials used and labour employed varied in such a degree as to preclude the possibility of even an approximation; while any comparison of the kind would be open to challenge by the advocates of the rival systems. I must, therefore, content myself by stating generally that the smelting of copper ores, averaging 10 to 15 per cent., and of such character as to afford suitable fluxing mixtures, will cost for smelting with coal, at 2s. 6d. to 3s. per ton, about £15 to £16 per ton of refined copper produced; and with good wood, such as box, ironbark, and blue gum, readily procurable, about £20 to £25. It is not possible, however, to state what will be the cost of lime, iron, salt, chemicals, fireclay, or even fuel or labour, in any particular part of Australia, every individual case demanding separate study; and in the fact that different processes are adapted to different conditions lies what I conceive to be the whole value, if any, of this paper. If all conditions were alike, we could compare the value of the different processes, and elect which in our opinion possessed the greatest merit; but the fact is that they each possess independent merit; and where one would be a complete success under certain conditions, it would fail if these conditions were different. Precisely for these reasons the ingenuity of the chemist has been brought to bear to adapt processes where none previously known were available; and the necessity of the case has been the means of bringing a new process into being. Hitherto progress in copper-mining industry has been greatly retarded in this Colony, owing to that

bugbear, the smelting establishment; and men have been frightened even to ascertain what wealth they possessed, for fear of being induced to ruin themselves by turning smelters. Now, however, in the far interior—in places removed hundreds of miles from centres of civilization—any man possessing ordinary intelligence may commence by amusing himself with small experiments, having for his stock-in-trade in starting, a pick and shovel, a pestle and mortar, an iron kettle, a few tubs, and sufficient ingenuity to build himself a small furnace for roasting 100 lbs. weight of ore. He will want also a fair stock of determination not to be beaten until he has made a pound weight of cement copper; and after he has succeeded he will probably enlarge his work sufficiently to admit of the production of half a hundredweight of copper, and ultimately half a ton at a time. There are, no doubt, many who will break down at the first onset, and give it up; but I should be doing Australians an injustice did I not believe that many will persevere until they have mastered all obstacles.

No attempt has been made—and, indeed, it would be beyond the limits of this paper, to enter into minute details; but sufficient outline has been given to enable the earnest man of progress to supply the rest. The thirst for starting metallurgic work, on an inexpensive scale, is increasing, not only in this country, but in every country; but the avenues for obtaining preliminary information for making a start are few and insufficient.

In the preparation of this paper I have been encouraged by the hope that it will lead in many cases to experiments on a small scale, which will develop into industries of importance. This I shall esteem my best reward for any trouble I may have taken in directing attention to this subject.

ON SOME TERTIARY AUSTRALIAN POLYZOA.

By Rev. J. E. Tenison-Woods, F.G.S., F.L.S., Honorary Member Royal Society of N.S.W., Corr. Member Royal Society of Tasmania, and Linn. Society of N.S.W.

[*Read before the Royal Society of N.S.W.*, 4 *October*, 1876.]

The following fossils were, with one exception, derived from the Mount Gambier polyzoan limestones, S. Australia. They correspond with the Middle Cainozoic, and while showing a tertiary facies are very distinct from the existing fauna, which is the more remarkable as polyzoa generally have a large chronological range.

The fossil polyzoa of Australia have scarcely attracted any attention from naturalists; the only description known to me being that of Professor Busk, in the Geological Society's Journal, 1859, and a paper by myself in the Proc. Royal Society, Victoria, for 1862. The field is therefore almost an untrodden one. The corals (Alcyonaria, &c.) have been more fortunate, and, thanks to the zeal and industry of the learned President of the Geological Society, Dr. Duncan, all the known Australian tertiary corals have been described.

Eschara cavernosa, n.s. Fig. I.

Polyzoary, pedunculate, palmate; cells deeply immersed and concave, with a raised margin, aperture very large and round, sloping towards sides, giving a hood-like appearance in front, two large raised pores at base of each side of cell, others, however, when worn, have one large opening. Mount Gambier; rare.

Eschara porrecta, n.s. Fig. II, fig. III, single cell highly magnified.

Polyzoary, pedunculate, palmate; cells immersed, very long and slightly lozenge-shaped mouth raised towards summit, circular, slightly notched in front, with a sessile avicularium pore immediately below, another pore with a long channelled opening about the middle of the cell, the rest of the surface of which is irregularly reticulated with openings. Mount Gambier; rare.

Eschara Clarkei, n.s. Figs. IV, V, VI, worn specimens, differently magnified, fig. VII, single cell, highly magnified.

Polyzoary pedunculate, palmate, or multiform; cells immersed, pyriform, rounded on the summit and raised round the margin, obtusely carinate in front; orifice rounded above, contracted below and slightly crescentic, with a raised margin; mouth sloping downwards so as to leave only half the orifice visible in front; a pore for the avicularium upon the summit. Surface, covered with distinct equal-sized rounded granules. The worn specimens of this fossil vary very much, the margin of the mouth narrowing like a funnel or spread out over the cell; slightly worn species have the mouth continuous into a kind of groove upwards. It is the prevailing form at Hamilton, and is generally found there in large expanded masses. At Mount Gambier it also occurs, but in short stems; the cells are quite visible to the naked eye, which makes the species one of the very few Eschara which is attractive in its ordinary appearance as a fossil, without being magnified. Muddy Creek, Hamilton, Victoria.

I have dedicated this species to the Reverend Vice-President of the Society.

Eschara verrucosa, n.s. Fig. VIII.

Polyzoary expanded, cells arched with a raised spirally striated margin, surface covered with warty granules, the margin with pores, mouth crescentic and deeply immersed. Mount Gambier.

Eschara rustica, n.s. Fig. IX.

Polyzoary branched, cells slightly raised, and marked on each side with three pores, gradually increasing in size and terminating in a large pore with a raised margin; mouth oval and raised, with a pore on each side of the margin for avicularia; the first pair of pores round and indistinct, somewhat closer than the other; second pair, round and deep; third pair much larger, oval and very deep; a sort of channel on each side of the raised terminal pore; the worn species have the mouth obliterated, and then look like rustic work in architecture. Mount Gambier; common.

Eschara elevata, n.s. (Monilifera?). Fig. X.

Polyzoary branched, cells raised and marked on each side with a linear series of pores, meeting at the apex of the cell; six or eight in each series; mouth simple, oval, and produced. Mount Gambier; rare.

This may perhaps be a worn species of *E. monilifera.*—Busk.

ESCHARA LIVERSIDGEI, n.s. Fig. XI, nat. size; fig. XII, magnified; fig. XIII, highly magnified.

Polyzoary expanded, cells obscure, mouth rounded above, expanded below, underneath three large pores disposed in a triangle, or two above and one below; on each side of the lower one obscure pores may be traced; lower lip of orifice with a narrow sinus. Mount Gambier; not common.

I have dedicated this species to your Secretary, the learned Professor of Mineralogy.

ESCHARA OCULATA, n.s. Fig. XIV.

Polyzoary expanded or dichotomously branched, cells much raised, subtubular, and covered with irregularly-shaped pores of various sizes disposed unsymmetrically; mouth circular, simple. The irregularity on the pores of this species makes it difficult to recognize if it is at all worn. In the old specimens they coalesce and look like mouths, in the younger species it appears as if there were always three oval pores radiating symmetrically from the mouth. Mount Gambier; common.

ESCHARA TATEI, n.s. Fig. XV.

Polyzoary dichotomously marked with elongated cells surrounded by a raised margin, which is expanded above, and slightly concave about the mouth; two rows of pores with four or five in each; mouth round, with a raised margin, which is sinuated below.

Observation.—This fossil when worn and the mouth obliterated shows only the raised margin of the cell with the pores enlarged, so as to form a kind of net-work in front. The pores sometimes join to form one row at the base of the cell if it is narrow, which, as the cells are crowded and not regularly quincuncial, is frequently the case.

This species I have dedicated to Professor Tate, of the Adelaide University.

ESCHARA BUSKII, n.s. Fig. XVI highly magnified, fig. XVII nat. size.

Polyzoary expanded, branched; the branches lobate, cells quincuncially arranged; mammillated so as to make a rounded raised margin to the cells, which gives the frond a warty appearance, very porous, with three larger pores on the inferior lip triangularly disposed, orifice round and immersed. A very common fossil at Mount Gambier.

I have named this species after Professor G. Busk, F.R.S., &c., the greatest living authority on Polyzoa, and almost, we may say, the founder of its classification.

Pustulipora ungulata, n.s.

Polyzoary cylindrical, dichotomously branched; cells very slightly projecting and disposed in circles at equal distances, longitudinal lines of cells of different circles spiral; transverse section shows six partitions rayed liked the spokes of a wheel. Common; Mount Gambier.

Tubulipora Gambierensis, n.s.

Polyzoary erect, adhering by a slender cylindrical root; cells dispersed on one side, but a few tubes sometimes opening behind near the margin; tubes simple, slightly recurved, long and crowded, distinctly traceable behind but faintly so in front; mouth simple, disposed in irregular spiral lines in front; when worn the mouths are very plain in lines almost encircling the cylindrical axis. Mount Gambier; not common.

Pustulipora corrugata, n.s.

Polyzoary cylindrical, branched or lobed in the thicker specimens; cells tubular, recurved, a very prominent irregularity disposed all round, and distant space between the cells corrugated or wrinkled. In what seems to be the older branches of this fossil the cells are much closer and more numerous, the corrugations on the interspace cannot be traced and the branches are terminated by congeries of sessile cells. Mount Gambier, limestone; very common.

Conclusion.—The publication of these fossils may serve to identify the beds in other localities. The zone itself, whether met at Mount Gambier, Narracoorte, Cape Otway, Portland, or Table Cape, Tasmania, is pretty constant in character, being one immense mass of foraminifera, polyzoa, with few broken shells, echini, teeth, &c., all showing a very deep sea deposit. It indicates probably the lowest depths of subsidence in our tertiary seas—and a depth of over 300 fathoms.

[Plates.]

TERTIARY AUSTRALIAN POLYZOA

Fig. I

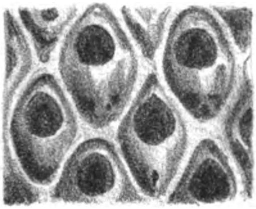


Fig. II

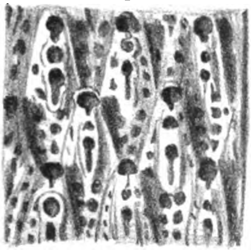


Fig. III

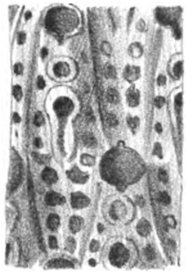


Fig. VI

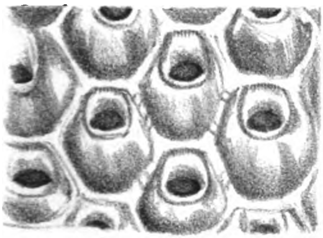


Fig. V

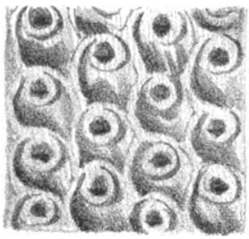


Fig. IV

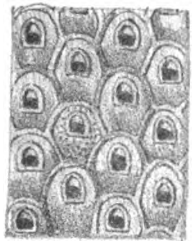


Fig. VII

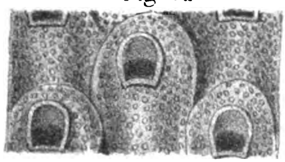
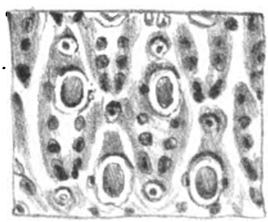


Fig. VIII

Fig. IX



I Eschara cavernosa
II & III Eschara porrecta
IV V VI & VII Eschara Clarkei

VIII Eschara verrucosa
IX. Eschara rustica

TERTIARY AUSTRALIAN POLYZOA

Fig X

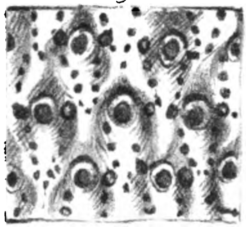


Fig XII

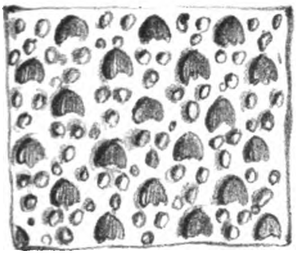


Fig XI

Fig XIII

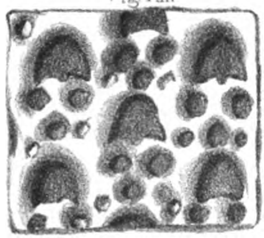


Fig XIV

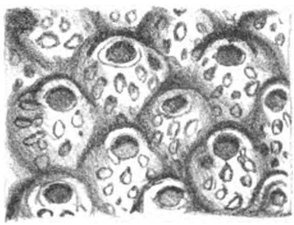


Fig XV

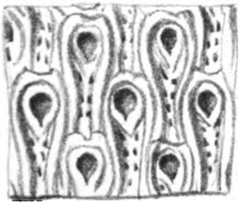


Fig XVI

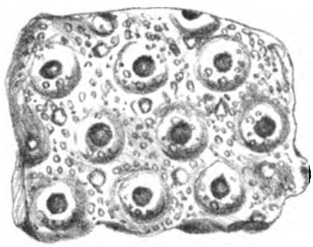


Fig XVII

Woods, Del.

S. T. Leigh & Co. Lith

X Eschara elevata (monilifera?)
XI XII & XIII. Eschara Liversidgei,
XIV Eschara oculata n.s. Syn E. oculata? Busk Jour. Geo Soc. 1859
XV. Eschara Tatei
XVI & XVII Eschara Buskii

METEOROLOGICAL PERIODICITY.

By H. C. Russell, B.A., F.R.A.S., Government Astronomer.

[*Read before the Royal Society of N.S.W.*, 11 *October*, 1876.]

A popular writer has recently said—"Surely in meteorology, as in astronomy, the thing to hunt down is a cycle. If it is not found in the temperate zones, then go to the frigid zones or the torrid zone to look for it, and if found, above all things lay hold of it, record it, and see what it means. If there be no cycle, then despair for a time if you will, but yet plant firmly your science on a physical basis and wait for results." *

In the spirit of these remarks, I shall attempt to bring together some facts bearing upon meteorological cycles; but from the difficulty of obtaining detailed observations for long periods and for many places, I am obliged to confine what I have to say chiefly to Australia, though I hope to be able to show you that we are bound by the same meteorological causes which rule the northern hemisphere, except in so far as local peculiarities modify the weather, which results from cosmical causes.

On the general question, Is a meteorological period or cycle likely to be found? a great deal might be said both in favour of a affirmative, and also of a negative answer.

We know that the earth, year after year, revolves about the sun at an unvarying distance; that the sun changes declination, going north and south over the same range, and in the same time; that with it follow summer and winter, trade winds, monsoons, ocean currents, and a host of natural phenomena in regular succession. We know that the average temperature, barometric pressure, and winds are practically constant quantities; nay, if our lot be cast in some favoured climes we can tell to a day when the wind will change and the fruitful rain come with it, and we might say, with some appearance of truth, there is no cycle but an annual one.

But if we look a little deeper we find that our *averages* here, as in other things, are very apt to mislead us, and that under all this regularity there is much uncertainty. It is true that the sun makes his annual excursions north and south, but we find the trade wind going at times farther north and south—is strong or weak, is surrounded by hurricanes, rain storms, and danger, in

* Lockyer—Solar Physics.

what at first sight appears to us a most uncertain way. By and by two years of like character appear, and we dream of a cycle, and the comfort and value that a knowledge of the period, if there be one, would give us. We started this inquiry ages ago, and in the present day we have heard much about meteorological periods, their causes and effects; and we have learned, theoretically or practically, to take a deep interest in the subject; and the very difficulty of selecting the *true cycle*, or perhaps the convenience of having a number to choose from, so long as *our* facts may be represented, lends a charm to it.

To the certainty of one cycle and its undoubted cause we have all been accustomed to give our adherence, but the very familiarity with it often makes us fail to see that the cause which rules in the cycle of greatest changes, viz., from summer to winter, must surely be sufficient by its probable variation to produce the minor changes which distinguish one year from another. We know that a slight change in the sun's position in the sky is sufficient to make the difference between winter and summer; and yet, when one year differs from another, we seldom suspect the grand cause of any variation. We call in theories of heated plains, unusual rains, or winds, to our aid in explaining the phenomena, while, if questioned at another time as to the cause of the heated plains, or the action of interior continents, we should, without question, attribute them to the solar influence.

Passing, then, from the annual cycle, about which all are agreed, let us consider some of the "Periods" which have been put forward as the results of observation and investigation.

The shortest is that which for many years pleased meteorological observers in Tasmania, viz., two years—a wet and a dry one alternately. Such a period does not take long for its discovery, and is exceedingly convenient in many ways, but after some twenty or five-and-twenty years of regular recurrence, during which observers naturally thought it was fully proved and established, a change came, and two wet years appeared together—1848 and 1849—and these were followed by two dry ones. 1849, as we shall see, was a memorable year in the climate of New South Wales and the other Colonies, but here it was memorable as the dryest year on record. There it was the turning point in the *two years'* period; and Tasmania, like the other Colonies, has since had an uncertain rainfall.

The next "period" is one of three years, suggested here by my friend, Mr. Tebbutt, in the *Herald*, 27th February, 1874, and by him traced through all his observations at Windsor for a period of fourteen years. For these observations, and also for those of Sydney between 1863 and 1875, it agrées remarkably well with the results; but, in attempting to trace it back through

the Sydney and South Head observations, it fails to represent the rainfall results; very much, however, may be said in its favour, and it has been remarked also in the climate of Ceylon.

Mr. Tytler, writing in Ceylon on January 30, 1873, says:—"In the Tropics, at least here in Ceylon, where we enjoy the regular changes of the monsoons, the basic period runs five or six years dry and five or six years wet. These make eleven, and they form the medium cycle of *three years*, the grand cycle of thirty or thirty-three years being three periods of the eleven years cycle." It is evident, therefore, that in Ceylon some traces of a three-year period may be found.

Mr. Ranken, in his work on the Dominion of Australia, speaks of years of dry weather in Central Australia, followed by years of drought. Making "years of a season, and not seasons of a year," he thinks that the immense area of flat and heated plain has a cumulative effect upon the weather, making season after season dry, until the tension becomes too great, and a great inrush of polar wind takes place, bringing abundance of rain, which spreads all over the burnt-up plains. Once there, the water takes several years to get away. It rises, and is again precipitated, and flood after flood follows. He thinks that these changes over the vast extent of flat country in a large degree modifies the climate of its coast margins.

Of this view it may be said that two well-known facts appear to be overlooked. In the first place, the evaporation on those interior plains during the summer months must at least amount to 12 inches per month; and overhead is steadily blowing the return wind of the trades, which, as the moisture rises, sweeps it away to the south-east, to be precipitated far from the interior of Australia.

As we have already seen, a period of five or six years has been recognised in Ceylon; and although I am unable to trace it in our annual results, the monthly rain tables show some signs of it. For instance, in April, 1845, there was a very heavy fall of rain; again in 1850 and 1855, 1861, and 1867. Another series may be found in June, 1846; heavy rain in 1852, 1858, and 1864; but I do not think any weight can be attached to these. They are selected cases, and by no means represent the general character of the seasons.

A period, however, of between six and seven years may be traced in our dry years a long way back; thus: 1872, 1865, 1858, 1852, 1845, 1838, 1832, 1826, 1820, 1814, 1808; and it is, perhaps, worth remarking, the comet of Biela has a period of six and two-thirds years, and, whether connected with the cause of our seasons or not, has passed the earth in every one of these years except the three last, which should be 1819, 1813, and 1807, to agree with the comet's seven visits.

There are some who believe in a period of nine years, and no doubt facts might be brought forward if the period could only find a champion. Of the next period in our list a great deal has been said, and for many years amongst observers of this climate this period of ten years has been considered, if not an established fact, at least one on behalf of which very much could be said, and a large amount of experience brought in as evidence.

For instance, the series following may be taken:—

	1789 1799	Dry years.
	1809	This year was certainly wet during the winter, but very dry during a part of it.
	1819	Wet year in the winter, but dry spring and beginning.
	1829 1839 1849	Very dry years.
	1859	Moderate year.
	1869	Latter half dry.
So	1808 1818 1828 1838	Very dry years.
	1848	Wet, but dry spring.
	1858	Moderate.
	1868	Moderate.

And so of other series which might be taken, the ten years seem to bring round the same weather; and it will be observed that in the early days of the Colony it was far more marked than it has been during the last thirty years. It is not, therefore, surprising that those who had bitter experience of 1808, 1818, 1828, 1838, 1829, 1839, and 1849, should be convinced that a ten years' period was beyond question; yet, I think, a careful examination of all the evidence reveals so many exceptions that it cannot be looked upon as satisfactory, and it will presently be seen that these years are better represented by the nineteen years' period than by any other.

Mr. Symonds, in the Report of the British Association for 1865, and *Nature*, 1872, page 143, says:—"In a table I prepared for fifty years' rainfall in Great Britain, (1) the wettest years are 1836, 1841, 1848, 1852, and 1860; (2) that these, all but two, form a twelve-year period, viz., 1836, 1848, 1860, to which we may now add 1872; (3) that the dry years were 1826, 1834, 1844, 1854, 1855, 1858, and 1864; that of these, all but three form a ten-year period, viz., 1834, 1844, 1854, 1864. All this looked very satis-

factory; but to make assurance doubly sure, I determined to make up a longer period; this I accordingly did for 140 years, and I was so disappointed at the total disappearance of both ten and twelve-year periods that I cannot say that I have closely scrutinized the values herein given." Mr. Symonds is also inclined to adopt Mr. Meldrum's theory of wettest years with greatest sun spots.

But no period has found such general favour as that known as the sun-spots, or eleven-years period. Its advocates assert that meteorological phenomena vary as the area of spots on the sun's surface; that when they are at a maximum we have the maximum of hurricanes, violent storms, and rainfall. To Mr. Meldrum, of the Mauritius, belongs the honor of first pointing out the coincidence of these phenomena, not only for the Mauritius, but also for a large number of stations, so far as maximum rainfall is concerned; and it appears that out of the stations examined sixty-seven have the maximum rainfall between 1859 and 1862. Amongst these are included two of the Australian stations, Brisbane and Adelaide, which, to a certain extent, agree with this theory, while the other three Australian stations, where a long series of observations have been made, are left out. It is not stated whether the sixty-seven stations were selected, but the three Australian stations omitted do not agree with it, while the two that are taken, to a certain extent do agree. Speaking of these rainfall investigations, Mr. Lockyer grows warm, for he says:—"A most important cycle has been discovered, analogous in most respects to the saros discovered by the astronomers of old. Indeed, in more respects than one may the eleven-yearly period be called the saros of meteorology; and as the astronomers of old were profoundly ignorant of the true cause of the saros, so meteorologists of the present day are profoundly ignorant of the true nature of the connection between the sun and the earth." No doubt this theory has for a time met the growing feeling amongst students of this subject, viz., that we must look outside the earth for the true explanation of its irregular as well as its regular meteorological changes; but I do not think that we find in it the final answer. In the first place, the sun-spots period is not an eleven years period; it is generally called such, but if we examine records of the maxima and minima we find a very different result, for the period between maxima actually varies from seven to fifteen years, nay, it is itself subject to variations in intensity as well as in time; and there is much that indicates an unknown cycle in this phenomenon also.*

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* Proctor has shown, page 188, "Science By-ways," that the sun-spot period cannot be traced in the earth's temperature, and the connection, if any, between it and rainfall and wind cannot, up to the present time, be considered proven, if indeed the evidence does not tend the other way.

In the next place, in the tropical limits of hurricanes, where the cycle is said to be most conspicuous, the truth of the theory has been denied by other observers, and I do not think that we can be satisfied with such an uncertain cause or coincident phenomena as the solution of our difficulty. It is true that the increase of sun-spots can be seen year by year, and to a certain extent the approach of a maximum can be detected in this way; but the sun-spot curve is a most irregular one—sometimes remaining almost stationary, and then, with a great outburst, running rapidly upwards. Besides, the great charm of a period is gone, if it may be seven or fifteen years long, as the case may be. For convenience I will here give the recorded dates of maxima and minima of sun-spots from "Loomis' Meteorology:"—

SUN-SPOT PERIODS.

Relative intensity.	Period.	Date of maxima.	Remarks.	Date of minima.	Period.	Remarks.
		Year.		Year.		
93	..	1778	Slight rise in curve—year 1781	1784	..	Rose nearly to max. by 1787.
111	11	1789	Rapid fall to 1791, then gradual	1798	14	Gradual rise.
73	15	1804	Quick fall to 1806, then gradual	1810	12	Slow rise.
44	12	1816	Gradual fall to 1820, then slow	1823	13	Steady rise until 1828, then slight fall, and again a rise.
58	14	1830	Quick fall	1833	10	Very rapid rise.
111	7	1837	Very quick fall to 1838, then quick fall.	1845	12	Rapid rise.
101	11	1848	Rapid fall to 1850, then a stop, and again a quick fall.	1856	11	Very rapid rise.
98	12	1860	Quick fall to 1863, then rise, and again quick fall.	1867	11	Very rapid rise.
140	10	1870	Rapid fall	....	..	—

The duration of this period has been variously stated as 11, $11\frac{1}{4}$, and $11\frac{1}{3}$ years, with how much regard to observations we have already seen. Taking the rainfall at Sydney, 1860 had the greatest recorded rainfall here; but another year given as one of the limits of maximum, 1862, was, with one exception, the driest on record, while the nearest approach in rainfall here to 1860 was 1841, which was not a year of maximum or minimum sun-spots, but is exactly nineteen years from 1860.

Using our rainfall observations, as has been done in Mr. Meldrum's discussion of the results at other places—that is, taking three years together, one on each side of the maxima and minima, we get the following results:—

Minimum period	1843–44–45	...	195	inches of rain.
Maximum „	1847–48–49	...	115	„
Minimum „	1855–56–57	...	147	„

Maximum	period	1859–60–61	...	183 inches of rain.
Minimum	„	1866–67–68	...	140 „
Maximum	„	1869–70–71	...	165 „

A period of twelve years has by some been thought to exist and be connected with Jupiter's revolution about the sun. No doubt this planet has a great influence on the solar system, and controls some of its meteor streams; but although I am fully prepared to admit the possibility of this action directly affecting our climate —and some confirmation appears to be found in such series as

1866 1854 1842	} dry	or—	1865 1853 1829 }

(the intermediate year 1841 was very wet)—yet it fails altogether when extended to other series, and rainfall measurements show no trace of it. We are therefore compelled to feel, like Mr. Symonds, disappointment that it cannot be traced.

A period of thirteen years is said to be recognised by the majority of observers in Ceylon, and that the intensity of the monsoons, rainfall, and cloudy weather, vary in this cycle.

In America there are some indications of a period of seventeen years, and it is said that one of the marked features is the regular return of a plague of locusts.

In the British Association Report for 1842, page 24, Luke Howard, F.R.S., attempted to prove a period of eighteen years in the climate of England, from his own observations at Ackworth, in Yorkshire; but when he afterwards (1845) attempted to predict the weather on this theory, he stated that his lunar period was modified by the facts then taking place, and I am not aware that this period has been advocated by any one else.

The next period, "nineteen years," we will pass over for the present, to mention an opinion expressed by Mr. Jevons, whose valuable investigation into the climate of Australia gave him every facility for forming a correct estimate of our climate. He says (at page 81 of his work):—

"I think it will appear pretty plain from the table of floods and droughts that the history of the Australian Colonies comprehends only two complete and two incomplete climatic periods, thus):—

Period.	Commencing.	Terminating.	Characterised by
1.	... ——— ...	1798 ...	Drought
2.	... 1799 ...	1821 ...	Flood
3.	... 1822 ...	1841 ...	Drought
4.	... 1842 ...	Not terminated in 1858	Flood.

There can be no doubt that, taken as a whole, the second period, 1799 to 1821, was one of great floods; but 1808, 1810,

1813–14–15–16 will ever be remembered as years of severe drought. Again, 1822 to 1841, 1825, 1830, 1832, 1836 were wet years

Mr. Tytler, in Ceylon, lays great stress on the cycle which has been observed there for thirty years, and he points out that visitations of the horrible leeches of Ceylon and most of the great landslips occur at this interval, and that the Singalese, with their traditions going back some 2,000 years, believe in an Edorvore Kala and a Weyokala of thirty years or so.

Of longer periods we have not much to say, though an attempt has been made to establish a period of fifty-six years in England (5 times 11¼), and I shall have occasion further on to bring forward some facts which seem to point clearly to a long period of upwards of fifty years in this Colony.

In England Mr. Symonds's most valuable researches on the rainfall have revealed some very interesting facts upon which a paper could well be written, but I will here only mention one or two. In the middle of last century a very severe drought began in 1737, and between 1740 and 1750 the rainfall was nearly 30 per cent. below the average; after that it gradually rose to 1775, when five wet years, 1772 to 1776, came together, and such a wet period has not been experienced since; after this the rain curve sinks rapidly again to 1785, then a slight rise to 1795, then a fall to 1805, then a gradual rise to 1824, since which time there have been some very wet years, but the average keeps the rain curve nearly even. The *very* dry years were 1788, 1806, 1826, 1734, 1737-38, 1744, 1854, and 1864. These facts I have taken from Mr. Symonds's work, as they are valuable for comparison with some of our history and traditions derived from the aborigines, especially the *great drought*, of which more presently. (*See diagram at end of this paper.*)

Coming now to the period of nineteen years, which I think was first suggested in my "Notes on the Climate of New South Wales, 1870"; but as the history of cycle-hunting has not yet been written, it is impossible to say that it has never been observed or published before. It is, however, certain that it was then first detected in our rainfall observations; and, so far as the information was then available, it was traced back for two periods. The rainfall diagram from this point of view was then published, including the results from 1840 to 1869. The following year (1871), Professor Smith, in his opening address to the Royal Society of N.S.W., took up the subject, and added considerably to the information I had published. The information about many years in the list then available was very meagre; yet the evidence again seemed in its favour, as may be judged from the following numerical statement:—eighty-seven years were examined; of these fifty-two fell into the nineteen-year period, twenty-five years were *not determined* from want of information,

and ten appeared to be exceptions—that is, of the determined years only one in six was as an exception.

Since then I have been able, by a diligent search for information, to add largely to our knowledge of the meteorology of past years; and, whatever may become in after years of the nineteen-years period, it has more in its favour now than ever before. Experience, however, can alone decide this question, and I have never put the theory forward as the *solution* of our difficulty. The evidence has convinced me that it represents our climatic changes, but nothing will please me better than a succession of fine seasons from now onwards, in direct opposition to what the present investigation leads me to expect; for such seasons would be of infinitely more value than the confirmation of the theory could possibly be. And I think I shall be able to show you that there is an amount of probability in its favour that will justify at least a careful examination; for if it should prove true, there is warning of seasons to come which may, if rightly used, be of the greatest value to the grazier and the agriculturist. A page of figures is not generally enticing to the reader, and I have, therefore, put into the form of curves the rainfall at each place from year to year, and for convenience they have been arranged, as Sydney curve is, in the nineteen-years period. It is, however, impossible to convey in this way an exact idea of the character of each year, for the curve is in some cases wholly distorted by rainstorms, as for instance, in 1844, where the curve is raised twenty inches by the rain-storm of one day; and again in 1868, a very dry year and counterpart of 1849, we have a rain-storm in February in which ten inches fell. So again of 1870, it was the excessive rain in March that masked the drought of six months of the year; but a very good general idea is obtained, and it seems, in my opinion, to illustrate the theory that we have every nineteen years a recurrence of similar weather. We have already seen that much may be said in favour of a nine or ten years period, that is about half the period indicated, and there is doubtless this sub-period which for three or four turns seems to fall in with the facts; but if we attempt to carry it through all the years it wholly fails. While tracing the nineteen years period through past history, we find no less than eleven well-marked lines in the series, and in many of them special characteristics will be found reproduced step after step in the series.

The second set of curves represents the rainfall at other places in Australia, and one station (Greenwich) from the northern hemisphere, which is put in for comparison; and although the theory does not at first sight seem borne out by the Greenwich curve, yet there are remarkable coincidences in the character of the curves, if they are viewed in the light of remarks to be made presently.

It will be seen that the Brisbane rain curve follows Sydney very well; it is below the average in 1859, above it for the two years 1860–61, very low in 1862, high again in 1863–4, very low in our memorable 1865, and so on, running to maxima in 1870 and 1873, like the rain curve at Sydney. Melbourne is sometimes with Sydney, as in 1862, 1865, 1868, and 1870, when droughts or heavy rains involved the whole eastern coasts; but it often accords with the Adelaide curve, to which I wish to draw your particular attention, as it bears strongly on the opinions expressed in this paper. (*Diagram* 1).

The Adelaide curve, if *inverted*, agrees very closely with that for Sydney, or, in other words, their rain seasons are the opposite of ours; and when the dry seasons prevail here, the rain precipitation, as I have before stated, is pushed southward, and recorded in Adelaide, and often in Melbourne. From 1840 to 1859 this fact is most striking, and, excepting 1854, 1864, and 1869, when, as before stated, droughts seemed to envelope the whole of Australia, we have a very marked agreement. For the first nineteen years, seventeen are the reverse of Sydney, two agree with it; for the second period, eight out of fourteen are the reverse of Sydney, and the others indifferent; so that, twenty-five years out of thirty-three, the rain curve at Adelaide is the reverse of Sydney. At Melbourne these phenomena are not so marked; but in many cases the same may be observed, notably of our driest year. 1849; it was at Melbourne the wettest on record.

The remarks just made form a very good illustration of what I have to state presently, viz., that the same cause, even a distant one, will not produce the same effects on different portions of the earth's surface. The force that brings us a drought usually carries rain in abundance to South Australia.

Let us now take the years in series, as they are arranged in the diagrams, only remarking that the year 1783 to 1787 are with us pre-historic:—

1802. A medium year, but there is little information.
1821. Moderate rain in July; heavy rain and floods in September.
1840. Moderate rains; heavy in July and September.
1859. Heavy rain in January and February; rain in July; very heavy and flood in September.

1803. Early part, very dry; latter part, wet and favourable.
1822. Early part, very dry; abundant rain in February; latter part, wet.
1841. February, dry; terrific rain in April 29; abundant rains latter part.

1860. Early part, wet; very heavy rain, April 28 and 29; abundant rains latter part.

1804. Heavy rain, April and October; moderate year.
1823. Heavy rain, March and October; moderate year.
1842. Moderate year; heavy rain, February; June, October, and November, dry months.
1861. Heavy rain, April and August; September to end of year, dry.

1805. Wet; floods in Hawkesbury and South Creek, March, October, and November.
1824. Wet; heavy rains, July, September, and October; Murrumbidgee in high flood, 20th, 21st, and 22nd October.
1843. Wet; very heavy rains, February, March, April, and August.
1862. Dry; heavy rain, February; rest of year very dry.

1787. Wet (?); when the colonists landed they saw recent flood-marks.
1806. Wet; very high flood in March; flood in October.
1825. Wet; abundant rains in March; floods in August.
1844. Wet; flood rains in June, and heavier in October.
1863. Wet; January, February, and March, very heavy rain; also August, and for sixteen days in October.

1788. Wet; heavy rain, February and August; October, November, dry.
1807. Wet; heavy rain and flood, January; wet in June; (no information end).
1826. Wet; heavy rain and flood, January; floods in August; September, October, November, dry.
1845. Wet; heavy rain, January and February; flood rains in April; August, September, and October, dry.
1864. Wet; heavy rain, February and March; high flood in June; September and November, dry.

1789. Dry; "the colonists suffered a parching thirst for several months."
1808. Dry; year very dry, but flood in November.
1827. Dry; dry year; heavy rain in April; little information to be had.
1846. Dry; dry year; heavy rain in November.
1865. Dry; dry year; heavy rain in November.
1790. Dry; February and March, heavy rain; *no rain* June to November.

1809. Dry; February and March, heavy rain; floods, May and July; rest of year very dry.
1828. Dry; April and June, heavy rain; end of year hot and dry.
1847. Dry; January, April, and May, heavy rain; latter part of year very dry.
1866. Dry; January, February, heavy rain; floods in June and July; August to end, dry.

1791. Early part severe drought; (end no information).
1810. Early part severe drought; tanks dry in February; flood in July.
1829. Early part drought; heavy rain, May and August; flood in November.
1848. Early part wet; February, April, May, dry; flood rains, July and October; end dry.
1867. January, February, dry; March, April, very wet; June, highest flood on record; end dry.

1792. Dry; heavy rain, April and September.
1811. Dry; early part dry; Sydney tanks dry for weeks in February; flood in March.
1830. Rain in January; floods, March and April; floods in October and November.
1849. Dry; early part very dry; heavy rain, May and July; end very dry.
1868. Dry; January and February, wet; March and April, very dry; May and July, heavy rain; end dry.

1793. Early part dry; rain in April and May.
1812. Early part dry; heavy rain in March; floods in November.
1831. Early part dry; floods in April and May; rain in November.
1850. Early part dry; heavy rain, March and April; flood rains, July and October.
1869. Early part dry; February and March, heavy rain; flood in May; heavy rain in November.

1794. Moderate year; very wet August.
1813. Dry weather; heavy rains in October.
1832. Early part dry; heavy rains in March and April; May, June, July, very dry; rain in August.
1851. Early part dry; heavy rain, February and April; May to September, dry; rain, October.
1870. Early part dry; March and May, heavy rain; June to September, very dry; rain, October and November.

1795. Dry; floods in January; March, wet; very heavy rain in August.
1814. Dry; rains early in April; early spring drought; rain in October.
1833. Dry; rains, February and March; spring drought; rain in September.
1852. Dry; March, rains; June, heavy rain; July, October, and December, dry; rain in August and November.
1871. Dry; March, May, and June, wet; July, October, December; dry; rain in August.

1796. Early part, no information; floods in August; wet in December.
1815. Very dry; rain in August and December.
1834. Early part dry (water scarce in Sydney); rain in August.
1853. February and April, very dry; heavy rain, July and August; September, October, and December, dry.
1872. February and April, dry; dry winter; rain in August and December.

1797. January, very hot; March and April, wet; May, June, July, very dry.
1816. No information; February, wet; high floods, May 30 and June 20; dry spring.
1835. January, very hot; March, wet; very dry winter; July, rain; dry spring.
1854. January, hot; rain, March, April, and June; very dry all the rest of year.
1873. January, hot; February, great flood; floods on the 5th and 18th June; August, September, October, dry.

1798. January and March, heavy rain; May, wet; very dry spring.
1817. January and March, heavy rains; May, wet; (no information).
1836. February and March, heavy rain; May, wet; snow in Sydney, June; cold, dry spring.
1855. February, March, April, wet; winter, very cold; dry, cold spring.
1874. February to July, very wet; winter, very cold; August, September, dry.

1799. Dry; January and February, hot and dry; floods in March.
1818. Dry; no information; floods in March; dry spring; rain, September.

1837. Dry; February, hot and dry; heavy rains, March; September to end of year, dry.
1856. Dry; March, April, May, heavy rains; very dry spring.
1875. Dry; floods in March; wet in April, May, and June; July to end, very dry.

1800. Early part dry; March, heavy rain and flood; seems to have had dry spring.
1819. Early part dry; February, March, and June, floods; dry spring; summer very dry.
1838. Early part dry; March and April, rain; dry spring; storm and rain, 10th and 13th October; 2nd November, day of humiliation on account of drought.
1857. Early part dry; February, March, and April, wet; September, November, December, dry; storm and rain, 6th and 7th October.
1876. Early part dry; April and May, wet; storm and rain, 7th and 8th October. For the remainder of this year we have yet to write the history.*

1801. A very high flood in March is the only information yet found.
1820. Summer very dry; Sydney water all gone, except in wells; floods in June and July; August, September, October, and November, very dry; heavy rain in December.
1839. Summer very dry; heavy rain in April; dry spring; rain in October.
1858. Summer very dry; heavy rain, April and May; very dry, July, August, September, November, and December; rain in October.
1877. The character of this year we have yet to learn, but the series in which it stands has been very dry from the beginning.

Bearing in mind that in this period it is supposed that the general character of the weather returns, and that it is only in some of the series that well-marked characters develop themselves, it is interesting to look back and see how the question of probability stands numerically, ninety years are under consideration; of these there are only three, 1830–48–62, that are decided exceptions. I do not mean to say that there will be the same wet or the same amount of dry weather in every year of a series, but that the general character of the years in each series will be the same; in one year, for instance, 1870, there may be an excessive fall of rain for two or three months, but take the year through, and it will be found very dry at the beginning; a wet

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* Moderate rain fell in October 1876 along the Mountain and Coast district, but it was still very dry in far west. In November moderate rain fell generally over the Colony, but the weather was very hot. In December no rain, 1st to 12th.

autumn, a dry spring, and then rain in the early summer, like other years in the series.

The droughts also show themselves very remarkably—1865–6, 1846–7, 1827-8, 1808-1809, 1789-1790.

So, of the well-known three years drought, it appears first in 1799, 1800, 1801; in 1818, 1819, 1820; in 1837, 38, 39; in 1856, 57, 58; and lastly in 1875, 1876; of 1877 we have yet to learn the character. In 1819 there were some very severe floods, and so in 1876 have we had similar heavy floods in some parts of the country, and so the great floods of 1809 find their representatives in 1866, fifty-seven years afterwards.*

Heavy floods are not always an indication of a wet year, very often they come in droughts, and naturally follow the great disturbances which then take place between the polar and equatorial currents; moreover, our rivers are so situated with respect to the mountains, that a heavy thunderstorm may make a flood, and in proof of this it may be stated that the first flood that ever alarmed the Hawkesbury settlers in 1799 came down on them without even an appearance of rain preceding it.

In looking at these droughts which are recorded, it is worth while to notice one or two of the traditions of the blacks. When Singleton was first settled, in 1821, the aborigines told the settlers that long before, there was a fearful drought, in which all the lower part of the Hunter River dried up, and the only place they could obtain water was at the head of the river, amongst the mountain springs; that here all the tribes—even those who bore each other the greatest enmity—collected, and for sake of dear life lived peaceably for the time. Still the drought dragged on. All the great gum-trees died, and vast numbers of the blacks, who were buried by their friends in a great field. In proof of these statements, the graves and dead trees still standing in 1822 were shown to the whites.† We may here recall

* Droughts are a much more marked feature of climate than floods, for floods are often the product of a great storm, and some of the greatest have come in notably dry years. Even in the fearfully dry year 1862 there was very heavy rain in February, and in 1865, a memorable year of drought, 9·877 in. fell in November, and of this 4 inches fell in one day. So in June, 1866, 3 inches fell on the 15th; so of 1849, 5·610 in. fell in May, and of this 2·640 in. fell in one day.

† In confirmation of the tradition of the blacks, it may be mentioned that a keen observer, who was sent by Captain King from Sydney to Melbourne along the coast, in 1802, says—"All the *great* gum trees were dead in every place I visited, and especially on Elephant Island, here I saw enormous dead trees, 5 to 6 feet in diameter, surrounded by a dense forest of young trees from 6 to 18 inches in diameter, these were only two or three feet apart, while of the old big trees there were only about twenty to the acre." The young trees were just such a growth as might be expected in that rich soil in the forty or fifty years which had probably elapsed since the great drought.

the fearful drought extending over many years, in the middle of the 18th century (1740 to 1750), as shown in Mr. Symonds's work; and we may mention that the drought of 1789 has its counterpart in England in 1788; that of 1814-15 here, in 1813-14 there; that of 1827 here, in 1826 there; that of 1837-38 here, in 1837-38 there; that of 1846-47 here, in 1844-45 there. Many other instances might be given, but these are enough. (*See diagram*).

In Africa, Livingstone records the drought of 1846-7 as follows:—

("South Africa," pages 17 and 18.)

"During the first year of our residence at Chonuane (1845) we were visited by one of those droughts which occur from time to time in even the most favoured districts of Africa.

"In the second year (1846) scarce any rain fell; the third was marked by the same extraordinary drought, and during these two years the whole rainfall did not amount to 10 inches. The Kolobeng ran dry, and so many fish died that the hyenas from the country collected to the feast and were unable to clear away the putrid mass. A large old alligator was left high and dry in the mud among the victims. The fourth year, 1848, was equally unpropitious, the rain being insufficient to bring the grain to maturity; needles lying out of doors for months did not rust; and a mixture of sulphuric acid and water, used in a galvanic battery, parted with all its moisture to the air, instead of imbibing more from the atmosphere, as it would have done in England. I put the bulb of a thermometer three inches under the soil in the sun at mid-day, and found that the temperature was from 132° to 134°. Rain would not fall, and dew there was none."

Again, in India we have 1837 standing out as their most dreadful year of drought and famine.*

Surely we have here enough to justify a strong suspicion, to say no more, that we have waves of drought passing over the earth, that we have an outside cause for the phenomena that has puzzled us so long—a phenomenon which we have every reason to believe is subject to laws as definite as those which hold the planets in their places, and the knowledge of which is fairly within our reach, if we have but patience to take the uphill way that leads to it. Nor must we at once assume that, if a period is proven at one place, we shall find the same at another. There is, I think, unmistakeable evidence of several involved periods; out of the combination of these with local circumstances come the results there observed; like the vibrations in musical notes,

* In 1872 rain almost deserted Bengal, and fell in great quantity in Northern India, while the rainfall of 1873 was the lowest on record, with the single exception of 1837; and 1862, the very dry year in Sydney, was also a year of drought in Central Russia.

they will "beat" just in accordance with the conditions existing. For instance, with one of the waves of drought we may have the conditions which shift the trade winds and send a comparatively plentiful rainfall; or we may have a number of forces at work which shall make the nineteen years cycle of one place the thirty years period of another.

As bearing upon this question, the history of Lake George is instructive, situated as it is in the mountains, with a well-defined catchment area, and no outlet. It forms a sort of natural rain-gauge, and should afford valuable information. I have been at some trouble to learn its history. In the latter part of 1820 it was discovered, and was then a magnificent sheet of water; but, fine as it appeared, the blacks declared they had seen it dry, and even covered by a forest—tales that looked, at the time, very improbable. The heavy rains of 1821 and 1822 filled it up considerably above what had been its level for many years, for it killed a great number of gum-trees round its margin, many of which were two feet in diameter. In 1824 it was twenty miles long, and about eight miles wide; from 1826 the water gradually dried up, and during the drought of 1827, 1828, 1829, its size got rapidly less; in 1828 it was fifteen miles long. In 1832 it was possible to ride over it, and it appears to have been dry, or nearly dry, from Kenny's Point to George's Gap. In 1836 it was visited by Sir Thomas Mitchell, and by him described as a grassy meadow like Breadalbane Plains, with dead timber on it. From this time it became a cattle and sheep run, at times having some water in it, which soon dried up. In 1842 and 1843, water accumulated; but in 1846 and 1847 it got quite dry again, and it was not until the floods of 1852 that any large quantity of water stayed in it. In the drought of 1866 and 1868 the water nearly all disappeared; but from 1870 it steadily increased, and by August, 1874, it was higher than ever before known, and again killed a number of trees around its margin. The water is now gradually decreasing (1876). It is therefore evident that from 1825 the lake decreased in size, and though sometimes of moderate extent after heavy rains, it soon dried up, and it was not until 1870 that the lake showed such decided signs of increase, rising to its maximum in 1874. It is difficult, nay impossible, to say in what years the lake filled up before, but judging from the seasons, it is very probable that it began to fill in 1816 and 1817, finding its maximum about 1822. Looking back at the droughts which came before these rains, it is most likely the lake was more or less dry from 1790 to 1800, and at that time afforded the experience related by the blacks in 1820; but taking only these points which are historical, we have the lake at its maximum in 1824 and in 1874, a period of fifty years.

On the Hunter River, about West Maitland, in the early days of the settlement, there were evidences of comparatively

recent encroachments on the south or town side, and on the opposite side a considerable portion of land had been left by the river, the current setting strongly on the town side; but the water in an ana-branch still surrounding the portion that had been left, flood after flood came great and small, and deposited mud, till the ana-branch was filled up, but no decided change came in the river's course, even in the greatest floods of 1857 and others, until 1870, when all at once, as it were, the river began to cut in on the town, and took away whole houses, even a terrace of small ones, and seemed disposed to cut off a large bend in the river, and many acres of the town, at the same time it made another large addition to the opposite side at that point, entirely changing its course. Judging from the great floods in the Hawkesbury in 1816 to 1819, it is probable that the Hunter was similarly visited; indeed, there was debris in the trees at the first settlement which left no doubt of the fact, and we are left to form an opinion of the date from the recent character of the debris, and the banks of the river where changes had taken place; and I do not think we can, from the known character of the seasons, place them at any other date than about 1817; or, in other words, we have evidence here of a similar period to that observed in Lake George; and it is interesting, in connection with the general evidence from Lake George and the Hunter of a long period during which the seasons seem to run to a climax, to note some of the facts in connection with the nineteen-year period, which seem to me to prove beyond doubt that there is a tendency here also to run at every third period to a maximum. To take the whole of the evidence on this subject which may be derived from the tabular statements would take much too long for our present purpose, and a few instances will be sufficient to show that this tendency exists, which is all I wish to do at present :—

1790. There was heavy rain in February and March, and it is said, "no rain fell from June to November," which was a very severe drought.

1847. There were heavy rains in the early part of the year, but from May to the end of the year was a very severe drought.

Again, 1809, one of the intermediate years, while generally a dry year, and specially so at the end, had very heavy rains in May and July, and in the latter month a very heavy flood.

While 1866, a similar year, and, like 1809, very dry at the end, had heavy floods in June and July.

The other year of this series, 1828, there was heavy rain in April and June, and a very hot and dry spring. We have yet to learn if that fearful drought, so well known of old, will reappear in 1885.

Or, taking another line of the nineteen years series:—

1797. January was very hot, March and April wet, and from May to the end of the year very dry.

1854. January, hot; March, April, and June wet; all the rest of the year very dry. Of the intermediate year, 1816, though there was, like these, a dry spring, there were very high floods, May 30 and June 20, and heavy rain in November.

While 1873, the fifty-seventh year from 1816, there were floods on the 5th and 18th June, almost returning to the day, and there was a dry spring.

It is needless to multiply instances—pages might be filled had we the time; those which have been given are sufficient to establish a very strong probability in favour of this law. To others, who have not investigated the facts, it may come with less force than it does to me; but those who are interested will shortly have before them more complete information about the meteorology of New South Wales for past years than it is possible to give in this paper.

Of the probable cause or causes which produce the effects we have been considering, volumes might be written; but space requires me to condense into a few pages my views on this subject; and, at the risk of leaving out some points of importance, I will try to be as brief as possible.

And first, allow me to say, that I still hold the opinion (which was expressed in my "Notes on the Climate of New South Wales" in 1870), viz., that it is wet or dry with us, just as the trade winds are weaker or stronger. In other words, that when from *some cause* the trade winds and N.W. monsoon set to the southward with more force than usual, we have a preponderance of northerly and north-westerly winds, and, of course, dry weather, because the region of rain precipitation is on the margin of the trades; and if this is pushed to the south of us, we have dry winds here, and an extra rainfall on the south coast; and if the trade wind is weaker we are in the rain region and have abundance of it; and I have by no means given up the opinion expressed at the same time, that the moon has a great influence upon our weather. Every year only adds to the facts which, to me at least, prove lunar influence on the weather; and had I time I should be glad to introduce here many of them from my own observation which go to prove the moon's influence in *forming* and in *dissipating* clouds, besides many collateral facts proving her influence on the atmosphere, volcanoes, &c., but these must be left for another opportunity.

Since 1870 many facts bearing upon the interdependence of the parts of the solar system have been brought to light, more especially by the study of meteoric astronomy, which seem to

throw light on many historical statements, and phenomena that have been observed in more recent times—phenomena which I I think a little consideration will convince us could not take place without producing very decided effects upon the earth's atmosphere.

It has been proved that the number of meteor streams is almost inconceivable; that they revolve about the sun at all degrees of inclination to the ecliptic, and in all sorts of periods; that many of them have their perihelion within the earth's orbit; and that in the meteor rings there is not a uniform distribution of the matter composing it, as has been shown by Professor Newton. With regard to comets also, facts seem to prove that they are not uniformly distributed in space, the sun in his onward course meeting more at one time than at another. "From 1600 to 1750 (150 years), only sixteen comets were visible to the naked eye; of these, eight appeared in twenty-five years (1664 to 1689); and during the sixty years (1750 to 1810) only five comets were visible to the naked eye, while in the next fifty years there were double that number."—("Kirkwood.")

From these known conditions we should expect that at times the earth would pass regions of greater meteoric density, in which the denser portions of meteor rings happened to come together; in this way, in all probability, so much matter intervenes between the earth and sun that his heating power is temporarily much reduced.* And every one who has watched the sun's heating power knows that it varies enormously, and the sun-spots do not seem to affect it. When these changes are observed in the solar radiation, all that can be seen with the telescope directed to the sun is a troublesome thickness and confusion in the air that is a bar to all delicate observations. At night the same thickness in the air may often be detected, and it reveals itself to the naked eye as a phosphorescent or milky appearance in what should otherwise be a black sky.

It is amongst these phenomena, the laws of which are daily

* And observation proves this to be fact, for whenever the sun has been seen in total eclipses its envelope has had a most irregular form, generally radiated. At times the corona, as in December, 1870, extended round 180° of the sun's circumference, while the other 180° was divided into three irregular rays by dark spaces which extended nearly to the sun's limb; or again, as in 1868, forming no less than nine rays extending from the sun to an immense distance into space. In 1870, photography proved that the corona extended for nearly double the sun's diameter on one side, while at another place the extent was only one-eighth of this, and it is evident that matter which is capable of reflecting light and heat must be also sufficient to prevent some of the radiation from the sun, and, as Proctor justly remarks, "Science By-ways," page 161, "no reasonable doubt can exist that the matter (forming the solar corona) is no other than the meteoric and cometic matter which other researches have taught us to recognise as plentifully strewn throughout the regions around the sun."

being brought more within our reach, that I think we must look for the causes which produce the proverbial uncertainty of the weather—an uncertainty which will doubtless disappear when we shall have learned more about the smaller elements of the solar system.

Here also we shall find an explanation of the dependence of the seasons of the two hemispheres, and the reason why a remarkable season in the north may be followed by a similar one in the south, or *vice versa.* For the causes of which we have been speaking may last days or months, and in the latter case would have a similar effect upon both hemispheres; but if the duration is short, the similarity in effect would probably not be noticed, for a very clear ether and increased solar effects would have different results in an Australian summer and an English winter.

In this view of our subject it will be interesting to refer to opinions which have been expressed by others. A well-marked depression in temperature has been observed in Europe in the months of February and May, and the celebrated M. Erman considered that "this is caused by the interposition of meteoric rings between us and the sun, and that the increase in temperature in August and November is caused by their preventing radiation from our globe, and possibly by radiation towards us of a part of the heat which they themselves receive;" and a "French physicist, M. Deville, who has examined in the most crucial manner the temperatures of the months of August and November since 1808, has detected the fact that in both months there is an increase of temperature about the period of the star showers, and a decrease in February and May, which he does not hesitate to ascribe to the influence of meteoric rings." (Guilemin, Ast.)

It may be mentioned that the 10th of August meteor stream, if disposed in the form of a flat ring, would encounter the ecliptic between the 5th and 11th of February, and would partially eclipse the sun's light.

As the data upon which these views were founded were for the northern hemisphere, it is interesting to inquire if any similar phenomena have presented themselves here; and, comparatively short as the time of our observations has been, we get several marked instances, and in every year examined there is a depression in the temperature curve between the 5th and 11th of February, and in nearly all cases it is on the 8th, 9th, or 10th.

In 1869 there is a marked fall in the annual temperature curve in February, although during February there was less cloud and cool south wind than in March and January. In the temperature curve for that month there is a great depression on the 10th, and on the nights of the 10th and 11th there were terrific cyclonic storms, with thunder and lightning, in Sydney.

In 1868 also there was a great fall in the temperature in February, and the average for the month was only equal to that of March.

In 1860, February temperature is again below January and March, and there was less south wind in February than in either of the other months. On the 9th, 10th, and 11th there were storms of thunder, lightning, and heavy rain.

Other remarkable depressions in the temperature of other months might be given of the same kind, but these will suffice of particular instances.

No one can, I think, look at the temperature curve plotted for a number of years without being struck by its strange anomalies. One year the temperature runs up suddenly to its maximum, and one month, or part of it, constitutes the summer; while in another year it rises to the same temperature and retains it for two or three months, the temperature of each being quite as high as the year of short summer. It is the same in winter. The curve is pointed, or rounded, in direct accordance with the circumstances which modify the sun's heating power. That these are between us and the sun does not, I conceive, admit of a doubt. Year after year the sun rolls on, and the spots which we see on his surface do not sem to affect his heating power, or if they do, almost inappreciably; while month after month, or season after season, strange irregular changes take place in the temperature, which can only be accounted for on the supposition that space between the sun and earth is not empty. To what extent these cosmical causes may interfere may be judged from historical statements.

Humboldt remarks with regard to the occasional darkening of the sun, that "a phenomenon of this kind, which cannot be explained by fogs or volcanic ashes, occurred in the year 1547 (24th to 28th August), and lasted three days. The sun was reddish, and so dark that several stars were visible at noonday" Similar darkenings of the sun's surface occurred in 1090 and 1208, but lasted for a shorter time—the former for three hours and the latter for six hours. Messier states that on the 17th June, 1777, about noon, he perceived an immense number of black globules pass over the sun's disc. Two other obscurations of the sun, that of the beginning of February, 1106, and that of 12th of May, 1706, during which, about 10 o'clock in the morning, it became so dark that bats commenced flying, and persons were obliged to light candles, do not appear to admit of any other explanation.

One other case from Roman history may be mentioned:—"At certain times the sun appears to be not of his wonted brightness, as it happened to be for a whole year when Cæsar was murdered, when it was so darkened that it could not ripen the fruits of the earth."—*Virgil*, Geor., Liber 1, &c.

Dr. Weiss of Vienna, says :—"Cosmical clouds undoubtedly appear in the universe, but only of such density that in most cases they possess sufficient coherence to withstand the destructive operation of the sun's attraction, not only up to the boundaries of our system, but even within it."

He considers that comets from these clouds, when the earth meets them, give ocular demonstration of the fact in a shower of meteors; and on the 27th of November, 1872, when the earth passed over the orbit of Biela's comet, such a shower actually took place, and a magnificent display of meteors was seen. At Turin, 33,400 were observed in 6½ hours; and in other places similar displays were seen; and if to these recorded meteors we add the far greater number that were not seen, we get some idea of the density of this stream representing only a faint comet, and how potent a cause for effects on terrestrial temperature may exist between the earth and the sun, all unheeded by us.

I confess that the account given of the darkening and red colour of the sun during a whole year does not seem to me so incredible as many have esteemed it; for we have in modern times two accounts of a similar phenomenon, lasting for weeks, viz., the *dry fogs* of 1783 and 1831. Many have attributed these to the action of volcanoes, and it is well known that in 1783 the fearful earthquakes in Calabria took place in February, and began a long list of volcanic eruption in the world; but in estimating the part played by volcanoes in these and similar phenomena, it is to be borne in mind that there must be a cause for the volcanic outbreak, and probably a cosmical one. Modern research has shown that they are subject to tidal effects like the ocean, or to distant attractive forces, and that eruptions are not caused by contraction of the earth's surface *only*, but by this and some other forces combined.

Besides, if great volcanic eruptions produced these dry fogs, we should have had many recorded in the world's history, and the peculiar and disagreeable smell would have been recognised; probably, also, rain would have thrown them down.

On the other hand, dust has been collected on the high snow-covered mountains, and when examined it proved to be meteoric dust.

Of the dry fog which came on suddenly in June, 1873, it is recorded that it extended from the northern coasts of Africa, over France, to Sweden, and over great part of North America, and lasted more than a month. Travellers found it on the summits of the Alps. Abundant rains in June and July, and most violent winds did not dissipate it; and, in some places, it was so dense that the sun could not be seen until it had attained an altitude of twelve degrees, and throughout the daytime it was red and so dull that it might be looked at with the naked eye. The fog

diffused a disagreeable odour, and the humidity ranged from 57 to 68, while in an ordinary fog it is 100. It had a phosphorescent appearance, and the light at midnight was compared to that of the full moon. The second instance :—

The extraordinary fog of 1831 excited public attention in the four quarters of the world. It appeared on the

Coast of Africa	August 3.
At Odessa	August 9.
In South France	August 10.
Paris	August 10.
New York	August 15.
Canton (China)	End of August.

This fog was so thick that it was possible to observe the sun all day with the naked eye, and without a dark glass, and in some places the sun could not be seen till it was 15° or 20° high. At Algiers, United States, and Canton, the sun's disc appeared of an azure blue or of a greenish colour. Where the fog was dense, the smallest print could be read even at midnight.

M. Arago, the great French astronomer, was at some trouble to prove that these fogs could not be comets, and gave as his principal reason that it would be impossible for the head of the comet to rise and set with the sun for more than a month, which is quite true; but it is nevertheless possible that the comet left part of his tail with the earth, while the head was too insignificant to be seen.

I will not stay to point out the bearing of these facts on the opinions previously expressed, for this paper is already too long A wide field for speculation is opened up when we look at some of the facts which have been brought forward to-night; and I think enough has been said to convince us that, in discussing the meteorology of the past or the future, we must ever bear in mind that the solar system is not stationary—it is rolling on into the unknown regions of space. What changes in the cosmical ether, what clouds of meteoric matter, what strange forces we shall encounter in common with other members of the solar system, is yet to be learned. But *space* is no longer empty: day by day, as science advances, we have to acknowledge new-found denizens of its infinite expanse, and recognise new relations between the earth and the manifold occupants of celestial space which surround us.

Albeit, we know but little yet about those with the presence of which we have been so long familiar. We have yet to learn the functions of electricity in regard to climate; we have yet to measure how much of it is produced by the friction of millions of meteors rushing through our atmosphere, not to mention numberless other phenomena comparatively within our reach, but which, so far, are by no means within our knowledge. The

celebrated M. Arago, after a profound investigation of this subject, uses words that are well worthy of study, and with them I will close :—

"Thus the various phenomena of the celestial vault and of meteorology, even while they appear by their irregularity to defeat the sagacity of the human mind, are ultimately found by profound investigation to be connected by sublime relationship."

DISCUSSION.

THE HON. JOHN SMITH, M.D., M.L.C., said this interesting contribution to the meteorological literature of New South Wales greatly extended the scope of Mr. Russell's former paper. He deserved great praise for the industry he had shown in hunting up the old records. He (Dr. Smith) had done something of this sort a few years ago for the Water Commission, hunting up notices of the weather in the newspapers, from 1802 downwards. He believed Mr. Russell had now exhausted all available sources, and they need not look for any additional information of value between the foundation of the Colony and the commencement of regular observations in 1840. All they had to do was to study carefully the facts collected. (In proof of the difficulty of getting trustworthy accounts of former years, Dr. Smith compared the statement of Captain Stokes, of the *Beagle*, as to the drought of 1838–9, with letters kept on record by a friend residing in Sydney. According to Captain Stokes there was no rain at all here for eight or nine months, including the period from November, 1838, to March, 1839; but the gentleman referred to mentioned several instances of rainfall in that period.) He (Dr. Smith) concurred in the theory of Mr. Russell, that we get our rain from the meeting of the cold polar wind with the warm moist equatorial wind (or the return trade wind). The zone of rainfall probably oscillates north and south, according as the polar wind or the equatorial predominates. A comparison of results at Hobart Town or Launceston, Wilson's Promontory, Twofold Bay, Sydney, Port Macquarie, Brisbane, and Rockhampton, would bring out the truth as to this oscillation. Last year Melbourne and Tasmania had more than the usual quantity of rain, while we had less. From this it appeared that either the return trade wind was too strong, or the polar wind was too weak for this Colony. If the fact of oscillation of the rain belt can be established, we should then go a step further and seek to ascertain the cause of the oscillation.

The Hon. L. F. DE SALIS, M.L.C., expressed his opinion of the high importance of Mr. Russell's paper. He (Mr. De Salis) firmly believed that there was periodicity in the weather of the Colony.

He had taken some trouble in examining the question. The rainfall was north or south according to the strength of the monsoon. This was ascertained by Mr. Todd, on the overland telegraph, where he had special opportunities for observation. We ought to avail ourselves of the trans-continental electric telegraph, to secure observations across the interior. He believed the sun to be the great motive power in all the weather. The moon also had an influence. He found by Admiral Fitzroy's work, that he was a powerful lunarist; and did it not stand to reason that these changes in cycles of nineteen years were connected with the moon running through all its course, as the eclipse proved, in nineteen years. Could anything be more likely than that the moon in going through all her grand changes would affect the weather? The moon affects the tide twice in every lunation; so it might affect the changes of the weather twice in every nineteen years. And he believed there were cycles of nine and a half years. Then the same weather occurred every thirty-eight years, that is twice nineteen years, or four times nine and a half years.

As to the nebulosity of the meteoric rings which darkened the sun, no doubt that also had some effect on the weather. There was a correspondence between the weather in England and here. He thought Dr. Smith's friend was not quite right about the drought of 1838–9. He had seen the diary kept by Mr. Close in those years, and it entirely corroborated the statement as to the extraordinary drought. The labours of Mr. Russell might lead to most valuable results, especially if they kept a record of the rain at different places in the interior. It would then be possible to prepare for a time of drought, and to mitigate its bad consequences. At present he believed three-fourths of the cattle in the interior had perished. And the drought was not over yet.

Mr. Russell, in answer to questions said, at every place on the earth's surface they would probably find a period peculiar to the place. There was some indication of a period of thirteen years here. The facts he had collected on the subject occupied 250 to 300 pages of manuscript. There was no proof that the sun's spots affected the weather.

The Chairman said, forty-two years ago he had collected in a book before him, materials bearing on this question, which confirmed Mr. Russell's view as to the causes of meteorological changes being cosmical. They were also connected with operations in the interior of the earth. He (Mr. Clarke), had traced changes of the weather as far back as 1101, and down to 1833.

A vote of thanks was passed to Mr. Russell.

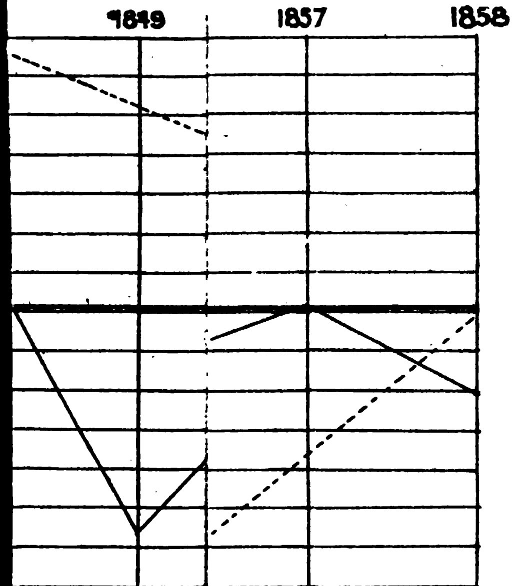
Mr. Russell, in further illustration of the subject, said the rainfall differed much at short distances. Sometimes there was

RIODICITY

875

DRY 1792?	WET 1800	DRY 1801?
DRY 1811	WET 1819	DRY 1820
DRY 1830	DRY 1838	DRY 1839?

LY PARTIAL. — M



No. 2.

CURVE SHOWING THE RAINFALL IN THE MIDLAND COUNTIES OF ENGLAND FROM 1730 TO 1860.

Each horizontal line is equal to 10 per cent. of the average rainfall, and each point in the curve is the mean of 10 years, thus 71 per cent. (1745) is from 1730 to 1740.

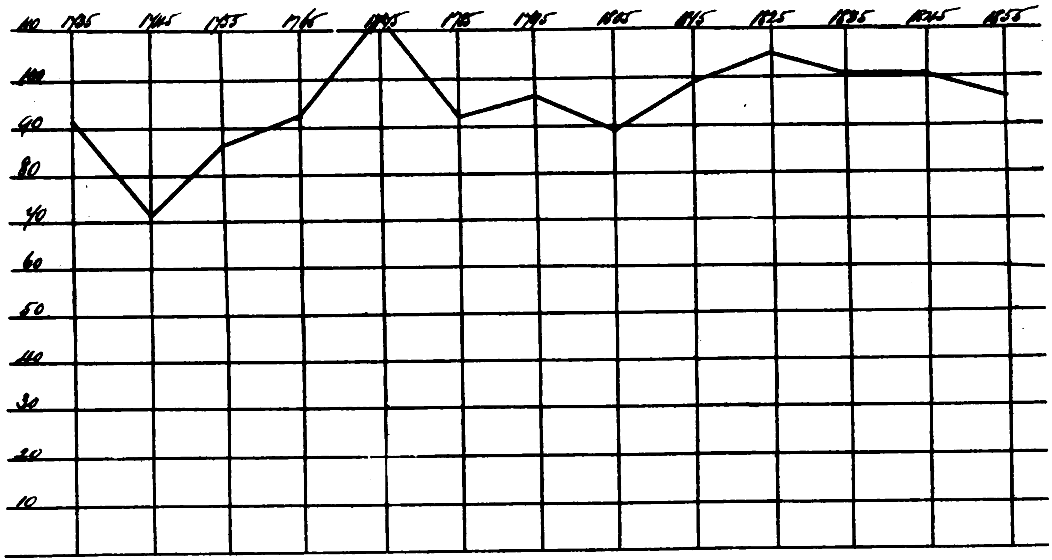


PHOTO-LITHOGRAPHED AT THE GOVT. PRINTING OFFICE, SYDNEY, NEW SOUTH WALES.

only 1-10th inch here while there was 1 inch at South Head. Tasmania has a very different climate from ours, quite insular, and there is no doubt a two years' period did exist for many years in Tasmania, but they never have really dry seasons there. The evidence of the nineteen years period here is I think so strong that it does not admit of much doubt.

[Three diagrams.]

EFFECTS OF FOREST VEGETATION ON CLIMATE.

By the Rev. W. B. Clarke, M.A., F.R.S., &c.

[*Read before the Royal Society of N.S.W.*, 1 *November*, 1876.]

At our last meeting we had the pleasure of listening to a very able and instructive paper on "Meteorological Periodicity," by my learned colleague, the Colonial Astronomer, an essay which exhibited the results of his diligence and thoughtful discrimination.

The topic was one in which, in the course of my own researches, more than forty years ago, entered into a somewhat wider field than Mr. Russell has chosen for his special investigation, since it embraced not only Meteorological but other Physical phenomena, and especially the internal as well as the external influences that produce either recurring or abnormal changes in the organism of this planet and the health of its inhabitants.

I confess I felt a desire, on the occasion referred to, to say something relating to the last-mentioned of these effects, but the hour was late and the speakers had been many, and it was on the whole better to have deferred my comments on Mr. Russell's remarks till the whole of his design had been completed. At the same time I deem it fitting to acknowledge that my own inquiries justify a full reception of many of his conclusions, although his range of observation was limited rather to the illustration of our Australian region than extended to the more universal evidences derived from ancient as well as modern instances of "Meteoric phenomena, Vicissitudes in the seasons, and Prevalent disorders contemporaneous and in supposed connection with Volcanic emanations," which was the subject of various essays published by me in the years 1833–4–5.

I propose to-night to call attention to something in a different direction which has also a bearing on the interests of the Colony, which may have interest for some here present, and which only takes the place which I expected would have been occupied to-night by a discussion from another quarter on a somewhat allied branch of inquiry, in which Forest vegetation will be considered under a different aspect, viz., in relation to Geological influences.

These latter will only be incidentally alluded to in the following remarks.

It may, perhaps, have never been seriously contemplated by numerous persons who have traversed this territory, that the progress of clearing land in such a forest region as New South Wales must have various effects on Climate and Sanitary conditions, and that civilization has destructive as well as conservative tendencies.

I would not dwell on the influence upon scenery of improperly conducted clearings. A consideration of that kind can hardly enter into the mind of a person who can deliberately leave acres of unfelled timber, bare of foliage, barkless, and broken by the winds, such as might be enumerated by the score in some of the once most beautiful tracts in the counties of Cumberland and Camden; nor is it necessary to point out the array of giants of the forest that stud the summit of the Dividing Range at the back of Heidelberg, in Victoria, or examples of landscape scenery partly ruined by the ravages of insects. It may be true that the custom of *ring-barking* trees is productive, for a time, of some extra growth of grass; but to say nothing of the deprivation of shade to flocks and herds, or of waste of timber, as in the cedar districts of our eastern coast rivers by the ruthless and wilful wielders of the axe, who leave upon the ground to decay in ignominy some of the finest and most noble of our trees, I cannot help expressing great surprise that gentlemen who in general character and condition of life are far above the hungry and uneducated selector or wood-splitter can allow ring-barking in places where grass can never grow, and where nature embellished the rocks with woods. Such I have seen to be the case in many a spot far away from those before alluded to. It is a questionable policy that some of such clearings should have been permitted, and till the "woods and forests" have been taken under the protection of Government, many a district of rich timber will continue to be foolishly destroyed, and many a scene of sylvan beauty will be desecrated. A remark of this kind may perhaps be laughed at by some as not worthy of thought; but I can afford to put up with such a reception, in the consciousness that ridicule would be undeserved. The late Bishop of Australia once said to me, as we travelled together through a region of naked, ring-barked trunks of trees, that he wished some thousands a year could be put upon the Estimates in order to clear them from the land, and in that wish I doubt not many besides the Bishop have concurred. [*See Appendix, No.* 1.]

I pass on to something of, perchance, greater importance than one of mere artistic or æsthetic taste. Yet, before so doing, I would call to the remembrance of the Director of the Botanical Gardens the sentiments expressed by him and his companions,

when in the autumn of 1873, the Hon. Mr. Barlee, Colonial Secretary of Western Australia, and myself looked down from the edge of the escarpment over the relics of the beautiful jungle that once nearly covered the whole space in that part of the Illawarra which lies between Rixon's Pass and the ocean at Bulli, when we found that that most lovely patch of greenery, containing plants that are now being eradicated altogether, was in possession of a Company, who were about to undermine it in search for coal. I only regret that Mr. Moore's engagements have hitherto prevented his intention of describing the plants in that isolated patch and bringing its features before this Society. Hoping he may yet realise his intention, I will omit any further allusion to the scene.

The paper of Mr. Russell had distinct reference to droughts and floods; and in seeking to discover whether any and what periodicity exists respecting them in Australia, he made no allusion to any possible effect of our forest vegetation on climate. That there may be such effects, however feeble in comparison with the more formidable cosmical operations of nature producing atmospheric and meteoric phenomena, I firmly believe: and in order to justify my own conclusions I will refer to and quote the statements and deductions of other observers, who are entitled to the fullest reliance.

It is well known that many regions which were fertile in ancient times have since become desert, and that countries which were incapable of bearing fruit are now amongst the best wine-growing districts in the world.

Various causes have, no doubt, operated on the large scale in some regions beyond what we are now specially concerned with: and a passing remark may be made that, whereas in older geological epochs Coal measure vegetation, and in younger down to the Miocene era, as shown by Professor Heer, a rich flora extended over large portions of the Arctic regions, Greenland, which since A.D. 1348 has been blocked up by ice, then being covered by forest vegetation; so in times of Biblical history the waste treeless tracts of Syria, Egypt, and Palestine were well wooded, and fertilised by living streams—the present barren Wadys occupying oftentimes the channels of once strong running waters. Tacitus (*Germania*, v.) tells us that fruit trees would not thrive in the very country where now the vine is most luxuriant. He calls it *frugiferarum arborum impatiens*.

"If we ask," says Professor Schleiden, in his most delightful work "Die Planze, The Plant, a Biography," "the cause of this mighty change, we are directed to the disappearance of the forests. With the careless destruction of the growth of trees man interferes, to alter the natural conditions of a country. We can, indeed, now raise one of the finest wines upon the Rhine, where

two thousand years ago no cherry ripened; but on the other hand, these lands where the dense population of the Jews was nourished by a fruitful culture, are in the present day half deserts. The cultivation of clover, requiring a moist atmosphere, has passed from Greece to Italy, from thence to Southern Germany, and already is beginning to fly from the continually drier summers there, to be confined to the moister north. Rivers which formerly scattered their blessings with equal fulness throughout the whole year, now leave the dry and thirsty bed to split and gape in summer, while in spring they suddenly pour out the masses of snow accumulated in winter over the dwelling-places of affrighted men.

"If the continued clearing and destruction of forests is at first followed by greater warmth, more southern climate, and more luxuriant thriving of the more delicate plants, yet it draws close behind this desirable condition another which restrains the habitability of a region within as narrow as, and perhaps even narrower limits than, before. In Egypt, no Pythagoras need now forbid his scholars to live upon beans (*Nelumbium speciosum*); long has that land been incapable of producing them. The wine of Mendes and Mareotis, which inspired the guests of Cleopatra, which was celebrated even by Horace, grows no more. No assassin now finds the holy pine-grove of Poseidon in which to hide and lie in ambush for the singers hastening to the feast. The pine has long since retired before the invading desert climate to the heights of the Arcadian mountains. Where are the pastures now, where the fields around the holy citadel of Dardanus, at the foot of the richly-watered Ida, supported 3,000 mares? * Who can talk now of the 'Zanthus with its hurrying waves'? Who would understand now the 'Argos, feeder of horses'?"

After this burst of eloquence Schleiden quotes the thoughts of the venerable Elias Fries of Lund, and adds—"A broad band of waste land follows gradually the steps of civilization. If it expands, its centre and its cradle dies, and on the outer borders only do we find green shoots. But it is not impossible, only difficult for man, without renouncing the advantage of culture itself, one day to make reparation for the injury he has inflicted; he is the appointed lord of creation."

* * * * *

"Before him lay original Nature in her wild and sublime beauty. Behind him he leaves a desert, a deformed and ruined land; for childish desire of destruction, or thoughtless squandering of

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* "Three thousand mares his spacious pastures bred;
Three thousand foals beside their mother fed."
—Pope's Homer, xx., 262.

vegetable treasures has destroyed the character of Nature, and terrified man himself flies from the arena of his actions, leaving the impoverished earth to barbarous races or animals, so long as yet another spot in virgin beauty smiles before him.

"Here again in selfish pursuit of profit, and consciously or unconsciously following the abominable principle of the great moral vileness which one man has expressed *après nous le déluge*, he begins anew the work of destruction." (Henfrey's Schleiden's Eleventh Lecture, p. 304–6.)

There is much in this reasoning of the German professor which agrees with the sentiments of the late Sir Henry Holland, Bart., who in an able critical essay in the *Edinburgh Review* of 1864, of Marsh's excellent work "Man and Nature," says:—"It is the forest which actively ministers to the climatic conditions of the earth, which, extirpated by the axe or restored by planting, changes both the face of nature and the distribution and destinies of human life." The simple name of Forest will hardly bring to the casual reader a conception of all that it implies; of the vast extent of the earth's "surface thus covered in every zone to the very confines of the Arctic Circle; of the various aspects and qualities of this great forest mantle, and of its relation to all the moving elements of the natural world. It is impossible to estimate, even by loose approximation, the actual extent of surface so occupied. We have given reasons for believing that the earth was largely covered with wood at the time when man first became its denizen." Mr. Marsh himself enters most minutely into the use and value of Forest vegetation, and describes with accurate care the effects consequent on the clearing of his native American lands by the axe or the prairie fire:—"With the disappearance of the forest all (he says) is changed. At one season the earth parts with its warmth by radiation to an open sky, and receives at another heat from the unobstructed rays of the sun. Hence the climate becomes excessive, and the soil is alternately parched by the fervour of summer and seared by the rigours of winter. Bleak winds sweep unresisted over its surface, drift away the snow that sheltered it from the frost, and dry up its scanty moisture. . . . The washing of the soil from the mountains leaves bare ridges of sterile rock, and the rich organic mould which covered them, now swept down into the damp low grounds, promotes a luxuriance of aquatic vegetables that breed fever and more insidious forms of mortal disease by its decay."—("Man and Nature, or Physical Geography as modified by Human Action." By George P. Marsh. 1864.)

The reviewer of this enthusiastic work points out where the author leans too partially to one side of his argument, but fairly joins him in affirming that "vegetation, under the form of woods, is

necessary, more or less, to the well-being of every country; and that many regions once fertile have become otherwise by the loss or curtailment of this magnificent provision of Nature for their covering." He points out that there is a remedy in "planting fresh forests where none exist—(*serit arbores quæ alteri sæculo prosint*)," and refers to Mr. Fox Wilson's memoir, read before the British Association, "regarding an extensive region in the Orange River territory of South Africa, bearing marks of having been formerly well wooded, but now utterly treeless and barren."

This will be noticed hereafter.

It has been stated by Dr. Kelly (Transactions of the Literary and Historical Society of Quebec, III., part 1, p. 46), from comparison of ancient documents, that the climate of Canada has not varied much for the last 200 years; and by other writers, that England in the time of the Norman Conquest, about 800 years ago, resembled that of Canada in its extremes of heat and cold, its dense covering of forests, and its growth of vineyards and accumulations of winter snows and ice. Grapes certainly ripen now in the south-eastern part of England when properly cared for, as I know they did on the walls and roof of my father's house; and, I believe, even as far north as Archangel, in Russia; but it is impossible to doubt that the clearing of the forests which formerly covered three-fourths of the country has modified the climate of England, whilst a change in an opposite direction has been said by Mr. Williams to have taken place by the introduction of the hawthorn hedges (*Cratægus oxycantha*) that now universally obtain. That author says, in his book on the Climate of Great Britain, that during sixty or seventy years previous to his publication, these hedges had produced wet summers.

Perhaps this method of dealing with the subject may be considered too vague to carry conviction with it; but it is only within a few years past that Climatology has taken the appearance of an exact science, and observations respecting any of the elements of Meteorology—still in its infancy, and only yet partially understood—had no existence in the distant periods to which, for comparison with the present, we are called upon partly to have recourse. Moreover, all climates are merely local; and what may be strictly true of one region may have little relation to the particular conditions of another. Nevertheless, there are certain general facts that may be so applied, and specially in such an inquiry as the present, though many of the circumstances may be wanting to meet the strict objects of what is called modern Science. Each country has its own peculiar characteristics, and there are many geological data to be considered in relation to climate before what applies to one region especially

can safely be made strictly applicable to another widely separated from the former. Still, there are certain conditions always capable of entering into the practical working of the problem, such as the effect of forest shade as preventing evaporation—the electrical agency of foliage, so great as to cause a single tree to produce sufficient electricity to charge a Leyden jar—the condensation of atmospherical vapour, and other agencies, which all belong to the question before us.

There is also a reciprocal effect of Climate on vegetation, which cannot be omitted, if perfect balancing of elements enter into the problem to be solved.

And yet we shall find that the Author of the Universe has provided peculiar and wondrous machinery to meet exceptional cases. Take, for instance, the influence of Vegetation on the atmosphere in the case of what a botanist of eminence, and an author of some interesting works on botanical subjects about half a century ago, included in his account of "Raining Trees." He enumerates the willow and poplar as producing even a gentle shower when grouped together. The properties of such plants as *Cornus* (*macula*), the *Tillandsia*, *Nepenthes distillatoria*, and other pitcher plants, which are resorted to by monkeys and mice, and especially the "Rose of Jericho" (*Anastatica hierochuntina*), that extraordinary succulent which inhabits the surface of a burning desert, were experimented upon by the author I refer to, Mr. Murray, F.L.S., who reported on the latter to the Horticultural Society of London.

Mr. Murray refers to a tree met with by Cockburn ("Voyages") at Vera Paz, in South America, which distilled water from the end of every leaf, and in a time of extreme heat had wet ground around it, and names a *Calla* and an *Agapanthus* as affording a counterpart. He further cites Glass's "History of the Canary Islands," as to a tree in the Island of Hierro, called *Til* by the natives, to which they applied the term *garse* or sacred, and which had the property of condensing vapour, so that rain, as it were, fell from it so copiously that it was received in a tank and meted out to the inhabitants.

To justify in some degree this to some apparently incredible fact, Mr. Murray mentions what is capable of more easy verification, viz., that in avenues of elms and Lombardy poplars, when a fog prevails, though the ground outside the leafy border be dry and parched, within the limits of the foliage it is wet, and he states the time when he noticed this to have been in the month of September, 1828, and that the place where this kind of rain fell plentifully from the trees was on the road between Stafford and Lichfield.

He adds a passage which I will quote entire:—"The great rivers of Europe have their supply in the Glaciers; but many of

the rivers in the New World owe their origin to the forests of America, and their destruction might dry up many a rivulet, and thus again convert the luxuriant valley into an arid and sterile waste; carried further, the principle extends to the great features of the globe. What the glaciers effect among the higher regions of the Alps, the *Pinus cembra*, and *Larix communis* accomplish at lower elevations, and many a mountain rivulet owes its existence to their influence. It rains often in the woodlands when it rains nowhere else, and it is thus that trees and woods modify the hygrometric character of a country; and I doubt not but, by a judicious disposal of trees of particular kinds, many lands now parched up with drought, as for example, in some of the Leeward Islands, might be reclaimed from that sterility to which they are unhappily doomed." (M. N. H., vol. IV., p. 32–34.)

I shall, before I conclude, put in evidence what will prove the truth of this suggestion from one of the group of islands mentioned.

But before I proceed, I wish to mention a statement made to me by more than one reliable informant respecting the power of Australian trees in time of drought to produce water from their roots. I was travelling with a friend in the month of January of the present year in the valley of Bylong in the county of Phillip, during the height of the drought. Among other circumstances brought to our notice was this—that water had made its appearance by springing up in several places where none had ever before been noticed, and the explanation given was that such water came from the roots of the gum trees. This opinion I heard uttered by several close observers, and I think it possible, when one considers the nature of the roots of these trees, and the effect of drought in contracting the wood, in checking the ascending sap and squeezing it out. I name this more to elicit observation and explanation from others than to lay it down as a fact sufficiently established; but I am inclined to believe there may be more in it than is "dreamed of in our philosophy" of droughts; and I know no other solution for the fact, if it be such, than the one I have suggested.

Professor Dobereiner, of Jena, mentions in the *Bibliothèque Universelle* that it has been noticed that on the high mountains of South America the trees continually transpired a quantity of water, even in the driest weather, the water falling sometimes as rain. This is a parallel case to that cited before from the island of Hierro.

Certain trees have been tapped for a supply of water, and the roots have often been found to discharge it sufficiently to assuage human thirst. These have been called the "Traveller's Tree."

Now, I believe it has been ascertained that the fibres of wood in trees are composed chiefly of carbon, oxygen, and hydrogen—

the two last in the proportion to form water; that the specific gravity of the sap is least at the roots, and that (which may be the cause of the hollowness of some of our Australian trees) it ascends in the greatest quantity in the newest layers, and that the innermost layers become clogged and hardened in the process of assimilation, so that the vitality ceases there, and the sap becomes deprived of the aqueous part of its constituents by the deposition of ligneous matter.

How water may be collected from *invisible* sources is a difficulty for chemists and naturalists, which I do not venture to solve. But, when we read of white ants, during a severe drought in the heated parts of Africa, finding plenty of moisture beneath the surface for making their plaster, though three inches deep the thermometer stood at from 132° to 134° Fahrenheit—and of other insects distilling (under experiment) from the castor oil plant 16 ozs. of water in twenty-four hours, which are the statements of Dr. Livingstone in his Missionary Travels (pp. 21 and 416, ed. of 1857), we must think that we know very little at present of either vegetable or animal life.

"We must," to use the great traveller's words, "leave it for naturalists to explain how these little creatures distil both by day and night as much water as they please, and are more independent than Her Majesty's steamships with the apparatus for condensing steam—for, without coal *their* abundant supplies are without avail."

It may be truly said that such phenomena as these can hardly belong to the "effects of vegetation on climate"; but in relation to drought, which is very intimately connected with climate, it may do no harm to show that there are alleviations of such a calamity for some of God's creatures, which defy the wisdom of man to parallel. We may thus be led to study the mysteries of the visible creation with humility as to what we cannot discern, and with hopefulness as to what, by well-tempered zeal and proper direction of what we may be permitted to discover, our Sciences will finally attain.

If, by a just employment of observation, we can arrive at any positive means of counteracting the adverse, or employing the friendly forces of Nature to our advantage, it is not only permitted us so to do, but it is our duty to do it, for the good of mankind; and it is not beneath the aim of rational and accountable beings to seek guidance as to the planting of a wilderness or the clearing of a jungle, if either be necessary, by inquiry as to the facts which may be obtainable by experience, and accepted as warnings or encouragements.

There are some facts in relation to the ability of certain trees to discharge water from their roots which will justify further reference to this branch of the subject, especially as the examples will be selected from Australia, and have a bearing on its sanitary conditions.

In a very important and valuable communication by Mr. Joseph Bosisto, M.P., one of the Commissioners of the Philadelphia Exhibition, to the Royal Society of Victoria, we find the characteristics and sanitary value of the *Eucalypti* shown by chemical analysis of their volatile products.

The author says—"The Mallee country plays a very important part in the climatic influences of Australia. * * * * * The nightly and morning dews of the mallee country are frequent in spring and summer. This is in part owing to the suspension of water in the air during the hot days from the river Murray and its tributaries, as they pass for a considerable distance through this scrub, but the greater amount of the dew moisture is owing to the exhalation of the leaves, for it must be remembered that, although the surface soil is dry and hard, the roots go down to the moist undersoil obtained from the salt-water springs. During the severe droughts to which this country is subject the trunks of these dwarf trees are *full* of moisture, but so poor of sap constituents that in one of the species in particular, when the trunk is cut down close to the roots, and placed in a bushman's panikin, a cool and refreshing draught of water is obtained, to the great relief of a weary wanderer in this lone and dreary scrub."

Mr. Bosisto goes on to say that it is held, on the lowest calculation, that in New South Wales and South Australia the mallee country is twenty times the area of similar country in Victoria, and that "96,877,444,000 gallons of oil are held at one and the same time in a belt of country over which the hot winds pass; and considering also that the same condition exists throughout the major part of Australia with the other *Eucalypti* as that which exists in Victoria, we cannot arrive at any other conclusion than that the whole atmosphere of Australia is more or less affected by the perpetual exhalation of these volatile bodies." He quotes the address delivered by Dr. Andrews, in December, 1844, before the Royal Society of Edinburgh, in which he states that "volatile oils, like phosphorus (*i.e.* in common with) have the power of changing oxygen into ozone while they are slowly oxidizing." He cites also Dr. Day, of Geelong, whose researches on this subject are well-known, and who has "demonstrated that the *eucalyptus* oils absorb atmospheric oxygen, transforming it into peroxide of hydrogen." He concludes from the facts demonstrated in his essay that "whatever change may take place in the condition of the atmosphere, arising from the free and large supply of these chemical bodies in the air, it is, from all known evidence, of an invigorating and healthy nature and character." "Death (he says) lives where power lives unused, and were it not that such happy and benign influences as those exerted by the *eucalyptus* vegetation existed around us, *independent of ourselves*, we might mourn our

fate. In conclusion, may we not say with some authority that the evidence set forth in this paper on our own vegetation is in favour of the *eucalyptus* being a fever-destroying tree?"—(*Essays, Victorian Catalogue, Philadelphia Centennial Exibition*, 1876, *p.* 87-91.)

The Baron von Mueller also notices the properties of the Mallee scrub with respect to water ("Fragments," ii. 57), where he says, "Radix horizontaliter longè procurrens largam aquæ puræ copiam retineat." In another of his valuable publications the Baron refers to Mr. Bosisto's experiments, and mentions also his own recommendations to that gentleman in 1854 to distil the *eucalyptus* oil, pointing out how greatly the growth of the trees which our settlers cut down indiscriminately is now encouraged and adopted in Europe, America, Africa, and New Zealand. He points out the sanitary benefits arising from our gum forests, shows how invigorating, as well as cheerful, is their presence, in comparison with the treeless plains, and ends a most delightful essay with these weighty expressions: "I regard the forest as an heritage given to us by Nature, not for spoil or to devastate, but to be wisely used, reverently honored, and carefully maintained. I regard the forests as a gift intrusted to any of us only for transient care during a short space of time, to be surrendered to posterity again as an unimpaired property, with increased riches and augmented blessings, to pass as a sacred patrimony from generation to generation. ("Forest Culture in its relation to Industrial Pursuits": a Lecture delivered by Baron Ferdinand von Mueller, C.M.G., M.D., Ph. D., F.R.S., on 22nd June, 1871.") [*See also Appendix No.* 2.]

In addition to the preceding remarks on the Mallee scrub, it may be proper to mention that there is a very useful paper by Mr. Cairns, in the Transactions of the Philosophical Institute of Victoria (vol. III., 1858) on the *Weir Mallee* (*a water-yielding tree*) of Australia. This tree fully bears out all that has been said above. It has been long known to the Aborigines, to the early settlers, and to botanists, as capable of supplying, when the roots have been cut to lengths of from 20 to 30 feet, and placed upright in a vessel, a pint or quart of pure water, a wonderful provision for thirsty wanderers in the bush. Mr. Eyre tells us that during his fearful journey along the coast of the Australian Bight in 1841, his two aboriginal lads procured him a third of a pint of water in this manner in a quarter of an hour, and says that "natives who, from infancy, have been accustomed to travel through arid regions, can remain any length of time out in a country where there are no indications of water." (*Central Expeditions into Australia*, by Edward John Eyre, vol. I., p. 350.]

We are not however to conclude that all *Eucalypti* will be as profitable as those mentioned; but the facts are, I doubt not, as stated.

Hakea stricta also supplies a small quantity of water in the same way. [*See Appendix No.* 3.]

I confess, however, I cannot understand statements made to me by more than one observer, that ring-barking trees is a greater source of water than allowing them to live. One friend has informed me that "within the last fifteen years about two-fifths of the timber in the watershed of the Hunter has been destroyed by sapping or ring-barking, and that the number of cattle and sheep is three times as great as it was fifteen years ago, and that the chief result which has followed sapping, *in every place and without exception*, so far as his observations have gone, has been that the creeks which were formerly dry watercourses, only containing water for a few days after heavy rain, have become permanent streams and, even in last year's very dry weather, showed no signs of failing. This result was quite unlooked for by those who sapped the land. There are, he says, on his own run two creeks flowing from opposite sides of the same range. One which flows west used to have water except in very dry seasons, and was taken up by selectors twelve years since. The other flowing east had no water, and so was not taken by selectors but was purchased by me, and all the timber in its watershed sapped. There is a strong stream of water running in it now, and has been for the last five years; whilst last summer the selectors on the other creek were very short of water, and are now sapping the timber so as to cause a flow of it."

It seems to me perfectly clear that there may be other physical causes than the one suggested by my friend for the local alteration in the water supply. Admitting with him, as I do, that the forests at the head of the drainage, on the main ranges, have not been touched, and that the average rainfall has not been diminished; perhaps, in the increase of cattle and sheep spoken of, trampling down the soil may have occasioned more water than of old to run off to the creeks instead of sinking into the soil. The solution suggested appears to me very much akin to the old logic respecting Tenterden steeple and the Goodwin Sands, the former of which was facetiously held to be the cause of the latter.

The mass of evidence supplied in the present paper from all parts of the world must, I humbly conceive, overbear any inference from unexamined actual phenomena brought against that evidence; but it would be unwise to test the supposition by clearing away every stick of wood from the ground with Vandalic extermination, which would be the only wise course if cutting down trees or killing them off whilst standing can really change dry gullies into living streams.

It is not to be doubted that judicious clearing is a benefit, and it may be admitted that grass does not always prosper in imme-

diate reach of droppings from certain trees, but this, which is due to chemical action, is but a small drawback from the actual sanitary blessings we have bestowed on us by the abundant growth of forests in which these trees are the principal members. A careful perusal of Mr. Bosisto's paper before mentioned, and the learned treatise on "Air and Rain—The beginnings of a Chemical Climatology, by Robert Angus Smith, Ph. D., F.R.S., F.C.S., 1872," will, perhaps, be sufficient to show that there is much which to the masses of readers and writers is a kind of *terra incognita*, which has as yet to be explored before we can dogmatize on some of the hidden operations of Nature in regard to vegetation.

I will therefore now bring forward many good examples from foreign countries as to the effect of "forest vegetation on climate"; and here I would remark that by "Climate" we are not to understand exactly what popular use makes of the word. "The single word 'climate,'" says a writer whom I have before quoted, "expresses one of the most important relations of man to the natural world around him—a relation which concerns human existence in its every part. But this word climate, taken in its largest sense, comprehends within itself all those elements of matter and force, the mutual influences and actions of which produce the phenomena so familiar to us under the single expression."

Dr. Daubeny (Lectures on its influence on vegetation) defines "the climate of a country to be its relations to temperature, light, moisture, winds, atmospheric pressure, electricity, and so forth; but assigns to its first place heat and its distribution. The present object is to illustrate how one of these relations, viz., moisture, is affected by forest vegetation, the reverse of the action understood by the Professor.

If the cutting down of a forest alter the atmospherical conditions of any spot, it may be said to affect the climate of that spot, and *vice versâ*.

If it have any effect on the supply of water to a river, then it affects its climate in another way; and in either case men's health or the advantages of life or animal existence in such spot may be affected.

There is therefore propriety in using the expression "climate" to indicate such a condition of things as existed before changes that may take place.

The late Professor Daubeny, whose work on Climate has just been cited, gives some useful illustrations of the effects I am engaged with. He quotes Boussingault's example of the Lake of Valentia in Venezuela, which has no outlet, but receives water from rivers and creeks, and where, in regard to the fall of rain and the humidity of the district a change was produced affecting the province.

Humboldt's account of the lake was that its waters were lessening, so that beautiful plantations of bananas and sugar-canes had taken the place of water—in some way like the change that has occasionally altered the condition of Lake George in this Colony.

This falling off was occasioned by the felling of timber, occasioning a deficiency of water in the rivers. Twenty-five years afterwards, Boussingault visited the lake and found its dimensions increasing, owing to the War of Independence having occasioned a cessation of clearings, so that less timber was being cut down, and rain fell in greater abundance than before.

That this is the true explanation was shown by other lakes in the neighbourhood, which had undergone no change of level, the timber on the surrounding mountains having remained in the state of nature.

The lakes of Neufchatel, Bienne, Morat, and Geneva have been mentioned as examples of similar diminution by Humboldt and Saussure; and Gasparin has shown that during the last century the annual amount of rain was stationary at Paris, Milan, and other places, leaving the inference that the clearing of forest country had produced greater evaporation.

The island of Ascension is next quoted as confirmatory; for the only spring existing in the island was dried up by the removal of the trees, and on the restoration of the timber the lost water returned.

This conclusion was, however, disputed by Boussingault, who contended that the trees impeded evaporation, because the island is too small to affect the rainfall. But Daubeny says, "It is enough for our purpose to substantiate the fact that by the removal of forests we have it in our power to modify the character of the country with respect to humidity, whether this be brought about in one way or the other; of which fact I apprehend there is abundance of proof."

To the instance of Ascension Island I would add that of St. Helena, which in 1506 was discovered to be entirely covered with forests, but when Dr. Hooker visited it a few years since he found five-sixths of the island barren, and the remainder occupied almost entirely by trees, shrubs, and other plants introduced from Europe, Africa, America, and Australia. The destruction in this case was by goats, and by the inroad of the new vegetation, supplanting the young shoots of native trees. In the days of its first occupation abundance of springs were found to rise from the hilly igneous rocks of the interior. But the country had become dry, and in some places waterless. In 1848, according to

the Island Almanac of that year, the rain had increased, which was attributed to the increase of wood. Floods had also decreased during the last eight years. It is said that during the present century the rainfall has nearly doubled. (Bombay Geogr. Society's Report, 1849–50, p. 55.)

A gradual decay of Great Britain was predicted in the *Times* newspaper in 1862 from exhaustion of vegetable mould, and Liebig exploded the idea that such mould, with tillage and manure, will suffice to prevent exhaustion; but Daubeny remarks, that many countries that once were fertile enough to maintain a large population are now barren and desolate admits no dispute, and he adds:—"To me the cause of this deterioration appears obvious as arising from the denuded state of those countries as regards timber, for which we need not go further than to many of the islands of the Archipelago, to parts of Greece, and even of Italy."

On the other hand, he maintains that where a country enjoys sufficient humidity, and the natural soil supplies suitable and sufficient mineral constituents, as proved by the Nile and by Naples, Tuscany, and even parts of Sicily, there will be no general exhaustion. And where the reverse is the case, he attributes it rather to the aridity occasioned by the destruction of forests than to the exhaustion of the vegetable matter itself.

Lastly, he cites Lower Egypt, where it has been usual to say no rain ever falls and the Nile does all the work; but since the late Pasha took to the planting of trees heavy showers have fallen about Cairo and Alexandria and in other parts of Lower Egypt.

As plague, locusts, and other vexations used to trouble the Egyptians when the Nile did not rise, it is surely as satisfactory to our medical as to our meteorological Section to know that an amelioration of the climate of Egypt has been partially effected through the instrumentality of trees; and who can tell what would be the further effect upon sanitary methods if some of our *Eucalypti* were brought as much into request in Egypt as, I understand, they have been in certain parts of Italy and elsewhere?

In addition to previous references to America, I may mention here that in Kentucky many brooks have become dry in summer which, for thirty years before the clearing of timber, were never known to fail; and in New Jersey, where the clearings were more extensive, some streams entirely dried up. On the other hand there are examples of the contrary—but the explanation given by the writer, to whom I am indebted for this statement is, that the tillage of the soil allowed the water to penetrate deeper, and cleared away the mass of leaves that caused the water to be more exposed to evaporation, though there has been no alteration in the rainfall.—[J. R. Mag. Nat. Hist., 1834.]

Looking to South America we find that similar conditions may be traced to those in the northern part of the continent. For instance, the inhabitants of the country assured Humboldt that the extreme aridity of the plains in about latitude 9°, between the Orinoco and the Andes, was occasioned by a diminished fall of rain, and that since the arrival of the Spaniards the trees had been destroyed. He says it is well known that in Caraccas the climate was destroyed by the removal of the trees, and that rain formerly abounded where now there is none, and after some reasoning, adds—"It results that the destruction of forests, the want of permanent springs, and the existence of torrents, are three phenomena closely connected together." Dr. Duncan shows the same results for the Deccan. The Cape de Verds show the same connection. Many others instances are named by Dr. Balfour, and, as we read in the Report of the Bombay Geographical Society for 1849, "thousands of similar instances might be quoted." It would be unfair to omit to mention one of the most remarkable of them. I allude to that of the Mauritius, quoted by Von Mueller. Dr. Rogers very recently issued a report "On the effects of the cutting down of forests on the climate and health of Mauritius." In 1854 the island was resorted to by invalids from India, as the "pearl" of the Indian Ocean, it being then one mass of verdure. When the forests were cleared to gain space for sugar cultivation, the rainfall diminished even there; the rivers dwindled down to muddy streams; the water became stagnant in cracks, crevices, and natural hollows, while the equable temperature of the island entirely changed; even drought was experienced in the midst of the ocean, and thunderstorms were rarely any longer witnessed; the lagoons, marshes and swamps along the sea-board were no longer filled with water, but gave off noxious gases; while the river waters became impure from various refuse. After a violent inundation, in February, 1865, followed by a period of complete dryness, fever of a low type set in, against which the remedies employed in ordinary febrile cases proved utterly valueless, pestilential malaria arose, exposed to which the labourers fell on the field, and, in some instances, died within a few hours afterwards." * * * * * Dr. Rogers very properly insists that the plateaux and highlands of Mauritius must be replanted."—(Von Mueller, Lecture, 22nd June, 1871, reprinted at San Francisco.)

Those who think the evidence afforded on the subject is not sufficiently scientific will hardly use that argument against Arago, who declares that "forests cannot fail to exercise a sensible influence on the temperature of the surrounding regions. The destruction of forests ought therefore to produce modification of our climates." He says also: "Clearing the wood from

a mountain is the destruction of a number of lightning conductors equal to the number of trees felled; it is the modification of the electrical state of an entire country; the accumulation of one of these elements indispensable to the formation of hail, in a locality where previously this element was dissipated by the silent and incessant action of the trees. On this point (he says) observations support theoretical deductions. According to a detailed statistical account, the losses occasioned by hail in the continental states of the King of Sardinia, from 1820 to 1828 inclusively, amount to the sum of *forty-six millions* of francs (£1,916,666 sterling). Three provinces, those of Val d'Aoste, the Vallée de Suze, and Haute Maurienne, do not appear in these tables; they were not visited by hail storms. *The mountains of these three provinces are the best wooded.* The warmest province, that of Genoa, the mountains of which are well covered, is scarcely ever visited by this meteor." * * * * "It is said to have been remarked in Italy, that in proportion as rice-fields multiply, the annual quantity of rain has gradually increased, and that the number of rainy days has augmented in proportion." Again,—"the wind exercises a *direct action* on vegetables, often very injurious, and which ought to be carefully distinguished from climatological action. It is against this direct action that curtains of wood, by forming a shelter, are especially useful. The direct influence of the wind on the phenomena of vegetation is nowhere more strikingly exemplified than in the Isle of France. The south-east wind, very healthy both for man and animals, is on the contrary, a perfect scourge to the trees. Fruit is never found on the branches directly exposed to this wind; none is to be found but on the opposite side. Other trees are modified even in their foliage; they have only half a head, the other has disappeared under the action of the wind. Orange and citron trees become superb in the woods; in the plain and where they are without shelter they always continue weak and crooked."—*Annuaire pour l'an* 1846.

Professor Laurent, of Nancy, instances Fontenay and Provence as places where the felling of forests has affected the climate. Wells and pits have become dry on this account. In the whole of the Eastern Pyrenees and the Herault, the felling of timber has been attended by serious consequences. The temperature becomes higher, wells and watercourses diminished, and the dryness of the climate was much increased. He also quotes similar results in the Vosges, Department of Garde, Nismes, Bezieres, Isere, &c.—*De l'influence de la Culture sur l'Atmosphère, &c.*

Professor Chaix, of Geneva, attributes the well-known floods and inundations of the Rhone, such as those of 1803, 1810, 1811, 1840, 1841, 1842, in part to the destruction of the great extent

of forest in the high lands of the basin of the river. He says the work of the axe was very extensive during the first twenty-five years of the present century.—*Extracts from a letter.* *J.R.G.S.*, XIV, 328.

A very striking instance of the mischief of clearing a forest injudiciously was given to me by a correspondent in the West Indies, the late Rev. Landsdown Guilding, of St. Vincent, some of whose remarks I quoted in the year 1835, in a paper of similar kind to the present. Writing in May, 1830, he says:—"The inhabitants of Europe may well be astonished at the quantity of rain which falls in hot countries. I shall subjoin an account of the quantity measured in this island from 1823 to 1829 inclusive." [*See Appendix No.* 4.] "This it must be remembered fell on the sea coast. If measured on the mountains it would exceed belief. I have several times slept on the high volcano of Morne Soufriére during a night of storm and thunder, when the water descended in a sheet, filling rapidly every empty wine bottle, and ploughing up the volcanic gravel into innumerable gutters, widening as they went into ravines of frightful depth. The climate has been considerably affected by the continued industry of man and his daily encroachment on the primeval forest. In the valley of Mariaqua, two fine cataracts which used to adorn the landscape and rush down the sides of Grand Bon Homme, are now not visible after heavy rain; and many portions of the cultivated lands in dry seasons suffer to a lamentable extent. So much has this change been felt, that laws have been passed to prevent the cutting down of timber in certain directions under heavy penalties. The planters in the suffering districts have long since seen with alarm the fatal mistakes of their predecessors in denuding the mountain ridges of their neighbourhood; and have, for many years, planted these parts again. But, in their short-sighted folly, trees were selected which attained but a very moderate height, merely because the wood was useful for cart work. To have remedied the serious evil under which they and their descendants were to suffer they should have entered the forest and selected the seeds and saplings of these giant figs and other fast growing native trees, which, though useless as timber, would soon by their height and magnitude have attracted, detained, and broken the rolling clouds, which now pass over to the interminable and pathless woods."

This valuable letter contains not only additional evidence of the influence of forest vegetation on climate, but gives an excellent hint as to the proper course to be pursued to remedy the effects of injudicious destruction of trees in a country subject to high temperature. In the 5th edition of Lyell's "Principles of Geology" (very much changed in the 10th edition) we have many interesting particulars relating to the subject in hand which will repay the trouble of reading.

The following extract from the *Times*, of 16th August, 1876, may tend to show that St. Vincent is not alone as suffering from destruction of woods in the West Indies :—

In reporting on the agriculture and industry of the Danish West Indian Island of St. Croix, Consul Palgrave has to state that of late the year's rainfall has barely averaged 34 inches, and in 1875 it was below 27 inches in the Christiansted division, and was quite inadequate to secure a moderate sugar crop for 1876. Mr. Palgrave says that the rainfall was certainly much more copious in former times. Traces of a tree-growth impossible with such a scanty moisture supply, of shrunken or dried-up pools, and of stream channels where nothing now flows, exist everywhere throughout the island. This unfortunate climatic modification has, it seems, become normal, not in St. Croix alone but throughout the Virgin Islands and the northerly region of the Lesser Antilles for the last fifteen years or thereabouts.

There are other instances which I would wish to bring forward on this occasion, the former of which, in September, 1835, I first noticed in the "Magazine of Natural History." I refer to the forest of Bialowieza in Lithuania, of which a description was edited by the Baron de Brincken, Chief Conservator of the National Forests of Poland, and member of the Department of Forests. This work was published at Warsaw in 1826.* It was afterwards, in 1845, briefly noticed by Murchison, De Verneuil, and Keyserling, in their great work on the "Geology of Russia and the Ural Mountains," in connection with an account of the forest, as the abode of the Bos Aurochs or Zubr, supposed to be the Bos Urus, or Bos priscus of antiquity, and a specimen of which was obtained and presented by Sir R. I. Murchison to the Royal College of Surgeons, for the investigation of Professor Owen, a description of which is to be found in the Zoological Society's proceedings for 1848, p. 12 to 13.

Sir Roderick's notice of De Brincken was in connection with an "Account of the Forest of Bialowieza, the habitat of the wild Aurochs or Zubr. By Count de Kraskinski (in a letter to Colonel Jackson, Secretary of the Royal Geographical Society of London)."

This forest was formerly a favourite hunting ground of the royal family of Russia, and remained free from clearings much after the fashion of an American forest. It contained, to a late period, numerous wild animals of the chase, of which the Auroch, or Bison, or Zubr was the chief.

We need not go further into the history of its inhabitants, but may refer at once to the Baron de Brincken's statement. Indeed, I have only time to make a few slight quotations from my own

*Mémoire descriptif sur la Fôret Impériale de Bialowieza en Lithuanie ; redigé par le Baron de Brincken, Conservateur en Chef des Fôrets Nationales de Pologne ; membre du Département des Fôrets à la Commission des Finances et du Trésor, Chevalier de l'Ordre de St. Stanislas, 2me classe ; Orné de quatre gravures et d'une carte. Varsovie. Chez Glucksberg, 1826, 4to, pp. 127.

abstract of his work. This forest lies not far from Orla, and is bounded by the old frontier of Poland and Lithuania, where it is about 25 miles in circumference, being seven geographical miles in length and six in breadth, lying in latitude from 52° 29′ to 52° 51′ N.

It is flat and sandy with lakes; the *Abies picea* occupies with the *Pinus sylvestris* four-fifths of the soil, of which the proportion of *humus* to the sand is as 1 to 4. The other trees are Taxus baccata, Quercus robur, Carpinus betulus, Betula alba, Alnus glutinosa, A. incana, Salices, Tilia parvifolia, T. grandifolia, Populus nigra, alba and tremula: Pyrus malus sylvestris: P. pyraster, Cerasus padus, Acer campestre, A. pseudo-platanus, Ulmus campestris, Fraxinus excelsior. There are also some shrubs which are enumerated in Gilbert's *Flora Lithuanica* (1781).

Here, then, we have a country of forests without mountains, and its climate peculiarly cold and severe. All the region north of the Carpathians, as far as the Baltic, is exposed to the cold and dry north winds from the swampy forest plains of the deserts of Russia and Tartary, whilst to the south of the mountains grow the grapes of Hungary and the fruits of the south. The mean temperature of Lithuania is about 44° F. Its weather is stormy, now cold, then intensely hot; warm by day in summer, cold at night. Near the forest of Bialowieza the cold is greater, and the harvests later by eight or ten days than at some distance from it. So much so, that sledges are used on the snow, whilst the peasants a few miles away are preparing to till their land.

Now, here we come into relation with the river-producing power, like that of mountainous regions. It is the *forest* which causes the waters of the heads of the Narew and Bug that belong to the great basin of the Vistula. The Narewka and Biala bear vessels even in the *forest*. And thus we find that high mountains and glaciers are not essential to the formation of rivers.

Humidity and vegetation act reciprocally on each other, and the leafy trees which have the greatest share in the action upon the atmosphere grow in the marshy and damp spots of the Forest of Bialowieza.

The value of this example will be seen if we refer to such principles as have been maintained respecting climate by such writers as Lyell and Daubeny. Malte-Brun also argues that the west winds in Poland, which blow for three-fourths of the year, are humid, the north are also moist though cold as are the south, and the east the coldest of all. Globes of fire, parhelia, falling stars, the Aurora borealis, and violent storms characterise Poland.

Sir Roderick Murchison (Russia and the Ural, p. 578) has these remarks:—"The hands of man have also produced and are still effecting considerable changes in large tracts of Russia, by the destruction of her forests and the conversion of her northern marshes into arable lands. A few centuries only have elapsed since northern Russia was a dense virgin forest, with vast intervening marshes and lakes, but now her gigantic pine trees are felled, lakes and marshes are drained, and the culture of corn is extended to the latitude of the White Sea. The natural recipients of so much moisture having been destroyed, we may (exclusive of the great spring *débâcle*, which in an extreme climate may have been always nearly the same) in great measure account for the sensible diminution of late years in the waters of the Volga and other great streams, whose affluents rise in those very countries where large tracts are now drained. For our own part, we can scarcely refrain from thinking that the axe of the miner (for wood is the chief fuel of the Russian miners) has been the cause of the increasing drought; an opinion which we formed in the Ural Mountains, whence the Kama and the greatest feeders of the Volga proceed, and where the inhabitants complaining of the annual decrease of water invariably refer this effect to the clearing away of their forests."

Can any other result, then, be anticipated for similar districts in New South Wales, of which an example may be found in the neighbourhood of the Icely Copper Mine, near Orange, where every stick of available timber has been destroyed, and fuel cannot be procured for a distance of six or seven miles. [*See Appendix No.* 5.]

Africa has also furnished examples which must not be neglected. Mr. James Fox Wilson, whom I mentioned before, has stated with great clearness and many details the case of the "Water Supply in the Basin of the River Orange or 'Garriep, South Africa," in the Journal of the Royal Geographical Society, vol. XXXV, the perusal of which will confirm much that has been already stated.

He points out that a great change in the external physical characteristics of the entire region between the Orange and the 'Ngami Lake has taken place since the country was first explored by Europeans.

He says the traditions of the natives carry back these changes to more remote periods, "when the country was far more fertile and better watered than at present; when the Ku'ru'man and other rivers, with their impassable torrents, were something to boast of. Moffat says the accounts of floods of ancient times, of incessant showers which clothed the very rocks with verdure, and of the existence of giant trees and forests which once covered the brows of the Hamhona hills, are wont to be related by garrulous elders to the utter astonishment of their younger listeners. In those ancient days the lowing herds walked up to their necks

in grass, and, filling their owners' milk-sacks with rich milk, made every heart to sing for joy.

"But travellers have before their eyes, in the immense numbers of stumps and roots of enormous trunks of the Acacia giraffe, where now scarcely a living specimen is to be seen raising its stately head above the shrubs, and in the ancient beds of the dried-up rivers Matlaurin, Mashua, Molapo, and others—positive demonstration of the departed former fertility of the lands of the Bechuana nation. In fact, the whole country north of the Orange River, and lying east of the Káláhári Desert, presents to the eye of a European, to use the words of the missionary just quoted, 'something like an old neglected garden or field.'"

Mr. Wilson shows next that this effect cannot be due to cosmical changes, but to "the characteristics of the region and the customs of its inhabitants."

The natural aridity of the soil, and irregularity of the rains (chiefly thunder-showers), with some other peculiarities, concur to produce occasional, if not periodical droughts, and that of 1862 is described in terms that recall to mind our Australian droughts somewhat intensified, and might be taken to describe the latter. The picture drawn by Mr. Wilson is one which in its main features may be easily recognised, and these, I may add, are features of drought in all countries lying within certain geographical limits with similar geological features. And so it has ever been since history has been written; witness the facts mentioned prophetically by sacred writers, especially the author of the book of Joel, in his first chaper, verses 4, 7, 10, 11, 12, 17, 18, 20.

The visitation of 1866 brings to Mr. Wilson's recollection Dr. Livingstone's statements respecting the drought he experienced on the Kolobeng River, in the Bakwain territory, during the first years of his mission work.

He goes on to answer the question, "*Is there any cause, besides the interior position of the country and the natural aridity of the soil, which occasions the advance of drought?*" He puts in large capital type the following words—"WE ASSERT THERE IS," and adds—"*and that the effects of that originating cause are controllable, and indeed to a large extent preventable.*" He then again puts in large capitals this sentence—"THE NATIVES HAVE FOR AGES BEEN ACCUSTOMED TO BURN THE PLAINS AND TO DESTROY THE TIMBER AND ANCIENT FORESTS." The Bechuana, especially the Batlapi and neighbouring tribes, are a nation of forest-levellers, cutting down every species of timber, without regard to scenery or economy." We need not consider the purposes for which the timber is appropriated, but may take Mr. Wilson's conclusion as sufficient. "By this means the country for many miles around becomes

entirely cleared of timber, while in the more sequestered spots, where they have their outposts, the same work of destruction goes on. Thus, of whole forests where the giraffe and elephant were formerly wont to seek their daily food, nothing is now left but a few stumps of the camel thorn, which bear a silent testimony to the wastefulness of the Bechuana. * * * *

"It appears certain that the further we proceed westward from the mountains of Natal and Kaffirland the less becomes the amount of rain bestowed by the clouds. The more denuded of trees and brushwood, and the more arid the land becomes, the smaller the supply of water from the atmosphere. The greater the extent of heated surface over which the partially exhausted clouds have to pass, the more rarified the vapour contained in them necessarily becomes, and the higher the position which the clouds themselves assume in the atmosphere under the influence of the radiating caloric; consequently the smaller the chance of the descent of any rain on the thirsty soil beneath, and the more the short-sighted colonist and ignorant natives burn the grass and timber, the wider the area of the heated surface is made; the further the droughted region extends, the smaller become the fountain supplies and the more attenuated the streams, till they finally evaporate and disappear altogether. Thus the evil advances in an increasing ratio, and unless checked *must advance*, and will finally end in the depopulation and entire abandonment of many spots once thickly peopled, fertile, and productive."

"In the case of the fountains at Griqua Town as having formerly poured forth an abundant supply of water, the accidental destruction of whole plains of the wild olive tree by fire near the town, and the removal of the shrubs on the neighbouring heights, are known to have preceded the diminution of rain, and subsequent diminution of springs, the subterranean caverns which acted as reservoirs in the bowels of the earth ceasing to be supplied from the clouds. There can be no question that, hitherto, vegetation, like animal life, has, in South Africa, been wastefully and ignorantly destroyed, in direct violation of physical laws, which can never be broken with impunity; and if we compare what is now taking place there with what has transpired in other arid countries, our conviction must deepen that it is not so much to the waywardness of Nature as to the wilfulness of man that we must assign the recent extension of the Káláhári Desert."

To those remarks the author adds references to other regions beyond Africa, some of which have not yet been mentioned by myself. For instance he names a case (mentioned in Chambers's Journal, July 4, 1863), where 400 springs in one small province of Persia, had failed; "the fatal consequence of permitting the

destruction of timber for fuel without making provision for a fresh growth."

He cites also "the British Colonies of Barbados (1), Jamaica (1), Penang (2), and the Mauritius (3) [see for the latter the note below*] where the felling of forests has been attended by a diminution of rain." The Punjaub, the Dekkan, Steppes of Tartary, Algeria, Texas, New Mexico, testify the same fact in all parts of the earth, that "trees are the true rain-makers." "But," he says, "we must not stop here, the evil is of such magnitude, and likely to bear so abundant a harvest of misery in the future, that the authority of law, wherever practicable, should be invoked, in order to institute preventive measures.

"Not only should fuel be economized, but the real interests of the British Colonies, for many long years to come, would most certainly be consulted by the passage of stringent enactments which should, in the first place, forbid, at any season and under any circumstances whatever, the firing of grass on field or mountain. Those Colonial Acts on this subject are not sufficiently stringent to be of much service."

In conclusion of his paper, Mr. Wilson points out the necessity of re-planting, and introduces among the trees recommended for planting along the courses of rivers by the late Dr. Harvey, Professor of Botany at Dublin (whom I remember to have seen in this Colony on a visit), some of the dwarfer and more leafy *Eucalypti*; and suggests the formation in ravines of artificial reservoirs and damming of watercourses as in Australia, recommended by Mr. Francis Galton. To this I would offer the further suggestion of planting near such reservoirs, as it is now discovered that such reservoirs as the Yan Yean for instance, if repeated, would collect all the drainage of a country only to expose their surfaces to greater evaporation than the water was subject to in its natural channels.

Speculation has recently turned its conjectures as to the possibility of creating a new inland sea in Northern Africa. In an abstract of a report relating to it, written in August last,

(1) Phil. Trans. II. 294. (2) Journal of Indian Archipelago. (3) Thornton's History of India. (4) Baude's Algeria. 78–81.

* The following is a report from the Mauritius correspondent of the Sydney *Herald*, published in the *Echo* of 25th July, 1876 :—

"The Legislative Council has had its usual number of sittings during the month. At one of the last of these the subject of re-wooding the island by the purchase by Government of land and planting of forest trees was again brought on the tapis.

Our forests have been ruthlessly destroyed, in some cases with the object of planting sugar-canes, and in others with the mere view of selling firewood, and now the result is apparent in continual droughts, and in the disappearance of the streams which were formerly abundant in every part of the island."

we find the following remarks, showing the effect of forest destruction in creating a desert:—

"Vice-Consul Dupuis, in his report this year on the trade of the port of Susa, Tunis, makes remarks on the subject of the project for submerging the region of Djerid by constructing a canal at Gabes, and so creating an inland sea. He considers that the recent surveys confute the idea of their having been formerly a connexion with the Mediterranean, and of the choking up of the passage for the waters, an idea perhaps based upon the inferiority of level to that of the sea; but in his opinion the observations made seem to endorse the fact of all the region having been under water. Arab writers unite in describing the country at the date of their conquest as having been very wooded and abundantly supplied with streams of water. The wood was cut down to facilitate the subjection of the tribes, who for above a century fought desperately for their independence, and whole regions are now condemned to sterility (save, perhaps, an oasis here and there), which were formerly rich in pastures, and interspersed with towns. The desert has been gradually extended in the district between Tripoli and Egypt, covering parts once fertile, and has in like manner encroached on the Tunisian southern frontier between it and Tripoli. The diminished heights and lowering of the Atlas let in the sands driven by the southerly winds, to which the more elevated and uniform heights of the mountain system oppose a barrier in more favoured Barbary States westward. In Morocco these winds are so tempered in their passage across the intervening heights as hardly to be recognized as the same which in Tunis dry up and parch the land in summer. Their action upon the sands accumulated by them at the foot of and in the passes of the mountains southward, where they sink into the plain, is the same as that seen at street corners, but on a large scale, and the sands are whirled and spread over the southern provinces. A form of this indraught and encroachment is seen in the winds which predominate in the fall of the year and fill the air with a minute and impalpable sand, very injurious to the sight; this sand, on examination of collections of it, is found to be very fine, while that around and in the valleys generally is coarse, the one being foreign or sands drifted from long distances, and the other indigenous or formed on the spot. It is presumed that the disappearance of the waters is due to the encroachment of the desert caused by the action of these winds during a long succession of centuries, aided by absorption and by evaporation occasioned by the presence of the vast scorching desert on the south, and also by the substances brought down by streams diminishing the depths and spreading the waters, and thereby helping in the work of desiccation. This was accelerated also by a decrease in the

water supply in consequence of the disappearance of mediæval forest, cleared away by the Arabs on and after their conquest. Hence the periodical rains, which once fertilized the country, have been replaced by heavier but rarer falls, which rush down the slopes and disappear in the sands or mix with the noxious waters of the lagoons before they can saturate the soil to any depth, washing away the earth and exposing naked rock on hill sides or high grounds."

We shall further gain considerable information by also considering the evidence offered by the East Indies:—

One of our recent Governors, Sir William Denison, whilst Governor of Madras, wrote thus to Sir Roderick Murchison, on 17th October, 1861:—"On coming down by the railway to the west coast we passed through a gap in the Western Ghauts, about forty miles in width and 1,200 feet above the sea. The Neilgherries rise 8,500 feet to the north of this; the Anamullays 6,000 to 7,000 feet to the south. The space between is a brown dry plain. After passing over about twenty miles of this, on a gradual descent, we, all of a sudden, plunged into the richest possible tropical vegetation, there being no change in the soil. On inquiring into the cause of this, I was told that the line of jungle marked the limit of the south-west monsoon, but why the monsoon should stop there I cannot tell. People informed me that a quarter of a mile was the amount of disputed territory between moisture and drought; that I might stand at one place and get but a slight sprinkling of rain, while a movement westward of a hundred yards would bring me into a tropical downfall. I have seldom seen anything which struck me as more remarkable. Why should not the wind sweep the rain up the plain, seeing that it has brought it thus far? I am dealing in questions, but in point of fact, these apparently trifling questions are most difficult to answer."—(Varieties of Vice-regal Life, vol. II., p. 131.)

Whether Sir Roderick was able to give, or did give any answer to the question does not appear in the correspondence printed in the book quoted from; but the question is not without answer, for with no direct allusion to Sir William it has been made in a valuable account of the "Effects of Forest Destruction in Coorg. By George Bidie, M.D., &c.;" read before the Royal Geographical Society of London on 25th January, 1869, and published in the 39th volume of the Society's Journal.

Coorg is near the centre of the western Ghauts, and not very far from the Neilgherries. The height of 5,000 feet is attained by the crest of the hills, to the east of which the country consists of low long-backed ranges with deep valleys, gradually subsiding in the table-land of Mysore, the average elevation being 3,000 feet. The Cauvery River runs through in a wide

basin with but little forest, but it is considered that formerly forests covered the whole province. It is still dense and lofty to the westward, and continues so for 10 miles from the crest of the Ghauts, whilst at 12 miles occurs the bamboo district, with smaller and more open jungle. Dr. Bidie says: "The nature of the forest, and also the kind of the trees found in it, form pretty accurate indices of the amount of rainfall." By a subjoined table by Mr. Richter, of Verajendrapetta, I find the means of seven years calculated monthly give a general mean of 111·66 inches of rain, with a temperature for four years of 66° 38 F. But Dr. Bidie states that in the dense jungle tract the rainfall varies from 120 to 150 inches, and in the bamboo district from 60 to 100 inches; whilst in two or three months, in January, February, and March of each year (according to the table) none falls. The characteristic trees in the dense jungle are—Michelia, Mesua (ironwood); Diospyros (ebony and other species); Calophyllum angustifolium; Cedrela toona (white cedar); Chickrassia tubularis (red cedar); Dipterocarpus, Garcinia, Artocarpus, Canarium strictum (black dammer tree); Euonymus, Cinnamonum iners, Myristica, Myrtaceæ, Vaccinium, Melastomaceæ, three species of Rubus, and a Rose. In this forest there is a dense undergrowth of moisture-loving plants, with splendid orchids on the branches of many of the trees. The bamboo tract is somewhat different, the line of approach being marked by the absence of ferns and the prevalence of a small Ardisia. The bamboos send up their branches in all directions, and in the eastern portion are teak and sandalwood. This forest is not continuous, but has grassy glades, and under the shade are good pasture grasses and gay annuals in the rainy season.

The rain in Coorg is almost entirely derived from the south-west monsoon—chiefly between 1st June and the end of September. The winds come loaded with rain, which deposit their freight on the Ghauts and the lower regions to the west. This rain is from condensation of the warm ocean vapour on the colder hills; and Dr. Bidie says there can be little difference whether the mountain slopes are bare or clothed with dense forest. He regards the forest on the high lands not as the parent, but as the produce of the rain, as the latter diminishes to the eastward.

As no regular records have been kept for the last fifteen or twenty years, he says there is not sufficient evidence to support his opinion that "the annual rainfall can be sensibly diminished by the destruction of the forest that has taken place." Yet the natives complain that their country of late years has become hotter and drier from want of rain, and that rice crops have been diminished or lost from failure of water in streams that used to run throughout the year. These changes they attribute

to the cutting down of forests on coffee estates; and, therefore, he proceeds to "inquire what effects the destruction of forests actually may have had on the climate and streams of the country."

He is led to admit that it is only twelve years since the felling of the forests in Coorg has taken place extensively, and that the effects are only gradually perceived, but do go on till they acquire a disastrous power. In Coorg there are 20,000 acres denuded of forest to make way for coffee, and the clearings are partly in the bamboo, chiefly in the dense jungle tracts. These clearings are along the banks and crests of low hills and the slopes and passes, which are densely wooded, and well supplied with springs, forming numerous streams. He then shows how these streams percolate the soil and are preserved by the forest and the matted soil. At the same time the shade of the forest prevents evaporation, the trees exhale much, and a portion is returned in dew or fog to be wafted away.

His information, during his tour in Coorg and Mysore, convinced him that "the facts elicited on the whole go to prove that the tropical forest is the *alma mater* of springs and streams. "Various instances," (he says) "have been brought to my notice of springs and small streams having become quite dry since the forest was cleared away in their neighbourhood, while in numerous cases those that used to be perennial only contain water now during and for a short period after the monsoon. Similar results have been found to follow the destruction of forests growing near the source of streams in all parts of the world." He next shows from Major Sankey's report on public works in Coorg for the official year 1865-6, that "great damage has been done to roads and bridges resulting from forest clearance, by the removal of the binding influence of tree roots to keep the banks" of the nullahs in position.

The remainder of Dr. Bidie's paper is occupied by reasoning to show the injury to the atmosphere, producing malaria and increase of heat, the forest always breathing "soft land airs" from the jungle, and to "these land winds is due the coolness of the nights, which will generally admit of sound slumber"; and in these words he quotes from Cameron, on the Tropical Possessions in Malayan India,—"That the cutting down of forests in Coorg has rendered both earth and air drier is shown by perennial streams having become periodical, by many plants perishing that used to flourish during the dry season, and by other remarkable changes in natural phenomena. He finally points out the effects of clearings on animal life, and the introduction of new and troublesome plants from other regions."

To complete the evidence from that portion of India alluded to by Sir Wm. Denison and Dr. Bidie, we must, in conclusion, turn to the valuable dissertation of Mr. G. S. Markham, F. S. A., Secretary to the Royal Geographical Society, "*On the Effects of the Destruction of Forests in the Western Ghauts of India on the Water Supply*" (published in the Society's Journal, vol. XXXVI., 1866).

The author introduces the district of Coorg, but does not confine himself to it. He says: "The destruction of forests has been one of the chief agents in effecting changes in the earth's surface, and the best methods of counteracting evil which may be caused by these extensive clearings is one of the most important questions that occupy the attention of physical geographers." This agent is now at work in the Western Ghauts of India, those rich and beautiful mountain-districts forming the backbone of the Indian Peninsula, and containing the sources of a water-supply on which the prosperity—indeed, the very existence—of millions depends." It is of an area of fully 7,000 square miles, to which the above remark refers; and it includes Wynaad plateau, which to the south borders Coorg, and is about 50 miles from the feet of the Neilgherries.

Wynaad is drained to the eastward by rivers that join the Cauvery; these are fordable in the dry season, and become furious torrents, 200 feet wide, rising thirty feet, dashing along with tangled branches and uprooted trees. In these respects they form a parallel to the rivers of Australia that descend from similar average height of 3,000 feet; the rocks are hornblendic granite and syenite, with basalt and quartz.

Coffee-planting commenced in 1840, and in 1866 there were 192 estates, covering 14,613 acres.

Passing the gap, mentioned by Sir W. Denison, in which the railway runs, rise "the glorious Anamullays and Pulneys, and the hills of Travancore, and these run on with breaks and peaks, under various designations, to Cape Comorin. The Pulneys were described by Mr. Markham, in his "Travels in Peru and India." The Anamullays were described by Dr. Cleghorn.

The rainfall on the Ghauts which is given above as about 112 inches, according to Mr. Markham decreases towards the south from 248 inches per annum at Mahabuleshwar, near Bombay, to 65 at Trivanderum, and to 30 inches at Cape Comorin.

At Mercara, at the centre of Coorg, it is 145 inches; at Nuggur, about 100; the mean of Nuggur, Coorg, Wynaad, and the Koondahs "receiving the whole force of the monsoon" have a rainfall of 200 inches; the aspects giving at Chumbra hill to the west 186 inches, and a few miles to the eastward 154.

On the highest peak of the Neilgherries, from 1847 to 1865, the average annual fall was 86·13 inches, the maximum being

102·83 in 1847, and the minimum 65·99 in 1848. "Although the rainfall thus varies according to local circumstances, every particle of moisture is wrung out of the clouds in their passage from the Indian seas by the intervention of the mountains;" and so far as this is the case, "the forests," says Mr. Markham, "which clothe their sides and fill the valleys and ravines on their plateaux, have the effect of regulating the flow of water to the eastward, but I cannot see that their presence or absence can have any influence on the actual amount of rain which falls on the hills." Of course this is sound reasoning, applicable to all very lofty mountains, whether in India or Australia, and probably so long as the primeval forests remained the supply in the rivers would continue at the usual average amount in a series of years. This consideration meets the argument that though in New South Wales the smaller streams have been partially or nearly altogether dried, as in the Illawarra, yet in the larger rivers, where at present the forests at their sources or on their banks have not yet been destroyed, the apparent body of water may be nearly the same as of old, though this is altogether conjectural in the absence of past or present measurements.

But the argument itself "*will not hold water*" any more than the river channels when destruction of the regulating forests is taken into account. Let us attend to the eye-witness before us. What, after his admissions, does Mr. Markham say?—

"The settlement of planters on the hills has given rise to wide-spread destruction of the primeval forest. The planters are occupied chiefly in the cultivation of coffee, to which has been recently added tea, and the quinine-yielding cinchona of South America. These three products give rise to the felling and clearing of forests in the formation of plantations—making a total of 60,000 acres of forest destroyed. Nor has the process by any means reached its limit, and a great change is taking place in the physical condition of the hill districts.

"One obvious consequence of the destruction of the forests is an increased rapidity of surface drainage, giving rise to sudden and destructive floods at the outlet on the plains, where the change of slope causes a diminution of velocity, and to injurious freshes in the irrigating rivers after they have reached the plains."

"The effect of vegetation is undoubtedly to retard elevation and to check the rapidity of drainage; and the removal of forests of course has an opposite effect. The hill districts of India are now affording proofs of this law of Nature. The floods caused by the monsoon rains are yearly increasing in size and violence." He gives several instances, and adds: "All this is clearly due to the extensive clearance of forests, owing to which the rain-water rushes off the surface instead of sinking into the earth and

forming springs." Again: "Major Sankey is of opinion that the original form of the hills may be permanently altered. The only remedy seems to be to preserve a broad fringe of trees and bushes above the road. Equally disastrous consequences arise from clearing below the roads which pass along a mountain side." * * * "Major Sankey, therefore, strongly urges the necessity of preserving a belt of jungle both on the upper and lower slopes of a mountain road. For the last twelve years a system of forest conserving has been established in the Madras Presidency, under the able and zealous superintendence of Dr. Cleghorn, with a view mainly to the preservation of valuable timber and of firewood, and to the retention of belts of forest near the sources and along the courses of streams. The construction of public works is by far the most important part of our mission in India, and their completion will form the chief, if not the only, justification of our occupation of that vast empire. As a branch of the Public Works Department, a forest agency is very necessary, both for the supervision of felling and planting on a proper system, so as to ensure an adequate supply of timber for public works and of fuel for railways, and for the conservancy of forests, to obviate the disastrous effects of indiscriminate felling on bridges, roadways, and irrigation works.

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"It must be remembered that one of the three products, the cultivation of which is now extending so rapidly in the hill-districts, will have the effect in a few years of supplying the place and performing the functions of the original forest. The beautiful foliage of the cinchona-trees, which after four years of growth are 20 feet high, will be as effective as the trees they have supplanted in preventing evaporation, regulating drainage, and receiving the moisture which is wrung out of the passing clouds. * *

"In the end of 1866 there were upwards of 1,500,000 cinchona-plants in the Government plantations on the Neilgherry hills, besides many others under cultivation by companies and private individuals. It is the intention of Government to plant 1,200 acres with cinchona-trees, and to keep another 1,000 acres as a reserve for further planting, if it should be considered desirable hereafter. * * * * * * * * *

"Still many square miles will be bare which once presented an unbroken surface of foliage. The forests will to a great extent disappear, and it is necessary that some other agency should be found to perform their duties, which are those of regulating and economising the drainage of the rain-water. * * * *

"It must be remembered, however, that the destruction of forests is very far from having reached its limit, that the rapid surface-drainage caused by it already effects much mischief in

the hill districts, and that as the felling proceeds these consequences may eventually be felt even in the Cauvery delta." * *

He suggests "the extensive planting of cinchona, teak, cork, vengay, black-wood, *Australian* and other valuable trees"; and concludes with naming other countries in which destruction of forests has been attended with injury. He quotes the Ural in Russia, Curaçoa in the West Indies, Hissar in Northern India, and the Orange River, in Africa, giving the names of reporters on each.

The preservation of forests in the *Northwest Provinces of India* was also long before the dates last-mentioned subject of earnest inquiry. The late Dr. Falconer, Colonel Cautley, and others, addressed the Government as to the necessity of active interference, and succeeded in inducing some vigorous measures for repressing the evil; so that for nearly forty years the value of forest vegetation has been recognized, and its reckless destruction condemned. In closing my argument, I think I needed nothing more satisfactory than the proofs furnished by Dr. Bidie and Mr. Markham, of the "Effects of Forest Vegetation on Climate," and of occasional injury by its Destruction.

But before I conclude, it may be useful to offer a few practical remarks as applicable to this Colony; indeed, I should be surprised if some of the preceding remarks had not already been accepted in that direction.

Not wishing to leave the question undefended or without satisfactory evidence as to its truth, I have endeavoured to strengthen my own conclusions by calling in a host of witnesses, who have shown by examples gathered from the East and West Indies, North and South America, Northern and Southern Europe, and Africa, that "Forest vegetation" has considerable effects on what in the extended sense is called "Climate"; that it exerts a protecting influence as well as an assisting power in preserving and increasing the supply of water, and that it is of vast importance to an arid region that such an influence should be encouraged and maintained.

Partly from these considerations, as well as from motives of a commercial kind, Commissions have been appointed and Legislation called into play, in some of our Australian Colonies, and in various other countries, especially in British India, for the conservation of the Deodar and other forests, and this has been a subject of discussion for a quarter of a century. (See Dr. Cleghorn's notice in British Assoc. Reports for 1865, p. 79.) Now, there are many circumstances connected with climate in this Colony which seem to parallel some of those which distinguish the physical character of India in relation to its floods and droughts. It may appear singular, but it is held by many close

observers and by hydraulic engineers, that floods are sometimes occasioned by the destruction of forests, as I have intimated already in allusion to Dr. Bidie, who holds the opinion that under certain conditions such clearings greatly extended will produce effects far beyond their immediate limits.

The peculiar vegetation of Australia, its geological structure, and the nature of its rocks and soils, may seem to be exceptional; but its droughts and floods have much in common with those of other countries where the physical conditions are not widely different: and even should our tentative conjectures as to periodicity ever become established facts, we should have then something more, and that something more reliable, to rest upon in our endeavours to benefit the natural conditions of our climate. The very close resemblance between it and that of Palestine justifies a brief quotation from Dr. Tristram's work on the "Natural History of the Bible." He says, "There is every probability that when the country was well wooded and terraced, and those terraces clad with olive trees, the spring rains were more copious than at present. Many light clouds which now pass over from the west would then be attracted and precipitated in rain over the highlands. At present, without any effort to utilize the bountiful supplies of Providence, three-fourths of the rainfall are wholly wasted." (p. 33.)

Is not this equally true respecting even those parts of this Colony that enjoy the greatest abundance of the "former and latter rains" in their season?

Ought it to be allowed, that in addition to neglect, there should be added wilful waste?

It has been my privilege at one time or another during my various journeyings to visit the sources of almost every important river and stream in this Colony, and it was not without some dread of the future that I have seen the possibility of the country becoming greatly deteriorated as to its water supply. At a time when the whole community is, or ought to be, excited as to such supply, would it not be wise in the Government and Legislature to make provision against wilful destruction of the woods and forests that border the courses of our rivers; to prevent clearing and ring-barking, except under regulations, the latter, as some times practised, being one of the most suicidal of schemes for the injury of posterity, as will be found, perhaps, at no distant date?

It may be said that our clearings bear but a small proportion to the timber that is left; but the difference increases in a geometrical ratio, and as population continues to arrive and spread, the land will gradually lose its protection of forest vegetation, and become year after year more and more arid and waterless. This, let us remark, is independent of effects from

the trampling of flocks and herds. Having noticed that many of our streams and rivers rise in swamps that lie in hollows of our hard, fissured, and dry rock formations, I ventured, in my Report to the Government, in October, 1851, to suggest that "it would be worth the attention of the Legislature, how best to preserve the integrity of the swamps," "satisfied that the greatest injury that could be inflicted upon the pastoral and other rural occupations of the colonists would be the introduction of the system of swamp drainage."

Perchance some may think it to be a stepping out of my proper province to repeat that warning, and may remind me of the old saying, "*Ne sutor ultra crepidam.*" But something is required to be done at once if our waters are to be conserved for times yet future, when manufacturing industries will extend. Not only ought the present destruction of timber that goes on in various parts of the country to be checked and regulated by law, but provision should be made for the replanting of many a naked tract of former forest vegetation. I might appeal to the Surveyor General on this subject, as he well knows that in some of our auriferous areas the whole of the timber has been ruthlessly cleared away. Similar practices have been employed by diggers in Victoria, and large areas have been completely denuded without any replanting, much (as I believe) to the vexation of that eminent botanist and public friend of the sister Colony, Baron von Mueller, whose labours in botanical science have earned him a name surrounded with enduring respect.

The views expressed by that learned and ever-active philosopher, in one of his elaborate treatises on Australian vegetation, fully bear out the testimony offered by so many other independent authorities as to the effects of "lofty and wooded ranges originating springs and rivulets for the formation of larger rivers." Nor is his language too enthusiastic when he says:—"On this I wish to dwell—that in Australian vegetation we probably possess the means of obliterating the rainless zones of the globe; to spread at last woods over our deserts, and thereby to mitigate the distressing drought, and to annihilate perhaps even that occasionally excessive dry heat evolved by the sun's rays from the naked ground throughout extensive regions of the interior * * * * * Even the rugged escarpments of the desolate ranges of Tunis, Algiers, and Morocco might become wooded; even the Sahara itself might have the extent of its oases vastly augmented; fertility might again be restored to the Holy Land, and rain to the Asiatic plateau or the desert of Atacama, or timber and fuel be furnished to Natal and La Plata. An experiment instituted on a bare ridge near our metropolis (*i.e.* Melbourne) demonstrates what may be done." The Baron

suggests in this not the indiscriminate clearing or ring-barking of trees, but "the mere scattering of seeds of our drought-resisting Acacias and Eucalypts and Casuarinas at the termination of the hot season along any watercourse, or even along the crevices of rocks, or over bare sands or hard clays after refreshing showers." Surely this would be far better than sowing the seeds of thistles, as was done years ago by one of the early settlers wherever he went—the origin of so much injury to his successors.

The paper from which my extracts are taken is one of the "International Exhibition Essays" of 1866-7, and will well repay a careful perusal. Nor is our New South Wales botanist of celebrity, the Rev. Dr. Woolls, less clear in the sound opinions he expressed in his recent lecture to the Horticultural Society of Sydney, not two months ago. He then pointed out in unmistakeable terms the mischief done to the community and to individual landed proprietors by the careless destruction of the forests, and the "murderous process" of ring-barking those wonderful *Eucalypti* which the providence of the All-wise Creator has planted in the great Australian garden—living types, as it were, of a tree "the leaves of which are for the healing of the nations"—and which, though too often foolishly rooted out or suffered to stand ghastly monuments of the covetousness of Australians, have found favour in Spain, in Italy, in America, and Northern Africa. Indeed, I now call to mind that the very first assemblage of living Australian trees that I ever beheld was in the plantation of a Dutch Baron in Southern Africa.

Showing the extent to which this practice is carried, we may find in the *Sydney Herald* of this very morning mention of seventy Chinamen employed in ring-barking on a single run, near Albury.

Respecting the value put upon the growth of *Eucalypti* in other countries, I need only refer to a volume published in San Francisco, entitled "Forest Culture and Eucalyptus Trees, by Ellwood Cooper, 1876," in which he repeats the substance of many of the publications of Baron von Mueller, and strengthens them by references to other writers. [*See Appendix No.* 6.]

Surely, whilst in other lands Australian trees are considered of so much importance as to have been dignified with the title of "The Trees of the future," it does seem strange that in Australia they should be held of comparatively little value.

So far as our water supply is concerned, a whole code of provisions is required, and the establishment of officers who in this Colony should have the same duties and powers as belong to the Conservators of woods and forests in other parts of Her Majesty's dominions, and in foreign countries also.

The Director of the Botanical Gardens could furnish a list of such trees and plants as would protect and encourage the water

supply of our rivers, and perhaps assist the elements in gradually ameliorating the severity of such a drought as many of our brethren are still passing through; for though we have been blessed on part of the sea-board with refreshing showers, there are even now thousands of sheep travelling in search of grass and water, while most of the runs throughout the country are occupied to their full capacity.

There are also spots along our coasts which should be planted to prevent the inroad of drifting sand. The cutting down of a natural scrub on the cliffs of Newcastle was followed by an inroad of sand which maintains its position; and a graveyard near Wollongong has been partially if not completely covered with sand, as is the case in numerous places on the eastern coast of England, and of which there are given some excellent illustrations in the late Sir Charles Lyell's "Principles of Geology" (vol. I., chap. 20).

The late Dr. Mitchell has been heard to say that, on his arrival, in the Colony, the sands that now exist as formidable dunes between Sydney and Botany had scarcely advanced beyond the shore. Should they continue their march, the flood of sand may threaten the burial of as many buildings as lie hidden beneath the undulating wastes of the Atlantic coast of France; but they, and even the sand-hills of Central Australia, may be made to obey the same law as the billows of ocean itself—"here shall thy proud waves be stayed"—by the careful and well directed employment of the means furnished by Him who gave that command of old; for Man, to whom the dominion of this lower world is given, is able by the simple use of natural contrivances not only to protect the flowing streams of water, but to shackle and enchain the desolating floods of harder material that have entombed churches and houses, and driven out inhabitants of many a seaside town and village in Europe.

If any apology be needed for introducing at such length the subject just discussed, let it be pleaded in the words of the poet:—

> Rura mihi et rigui placent in vallibus amnes
> Flumina amem, silvasque inglorius * *
> * * O! qui me gelidis in vallibus Hæmi
> Sistat et ingenti ramorum protegat umbra;
> Felix, qui potuit rerum cognoscere causas.
>
> [Geor., ii., 485.]

APPENDIX.

The main portion of this paper having been struck off, before I had time to introduce some additional matter which I had intended to incorporate therewith, it has been deemed advisable to introduce it under several heads in an Appendix, together with the meteorological observations of the Rev. L. Guilding, in St. Vincent's Island, West Indies, mentioned in the text.

No. 1 (*p.* 2).—*Ring-barking.*

This process is defended on the ground that it enables a little more grass to be grown at the roots of trees that are dead, and that it does no harm to clear away useless scrub. Unfortunately, however, it is proved (See Chambers's Journal, part 153, Sep. 30, 1876, p. 591) that gum-trees do not lessen but assist the deep supplies of water; and the objection I have expressed is not to the clearing off of useless timber, but to the destruction of iron-bark and others of our most valuable timber-trees, evidence of which is easily collected, not only from the dead forests of thirty or forty years existence, but from what is still going on in hundreds of fresh localities. At present no statistical returns have been made; but it would be useful to know how many thousands of acres have thus been disfigured, and what is the annual rate of destruction, and in what ratio the evil has been counteracted by re-plantation. Might not these be fit items in the Registar General's annual Returns?

The time is fast approaching when the future occupiers of land that cannot for ever be held as much of it now is, will be loud in their complaints respecting wood for fencing, bridges, railway-sleepers, and other wood-consuming ingenuities, to say nothing of fuel, where coal is not, and the demands of mining industries, which are insatiable, will be loud in denouncing the want of foresight in their predecessors.

The clamour has already been begun, and it will not cease till it makes itself unpleasantly heard.

No injustice is intended to the sheep-farmer by such remarks as these. But sheep-farming may be carried on without injury to the forests, by the act of re-planting judiciously to compensate land now injudiciously laid bare or disfigured by some who are killing the bird that lays the golden egg.

No. 2 (*p.* 11).—*Use of Forests.*

Let us notice what a writer in a popular English work (edited by William and Robert Chambers) entitled "Information for the People," 5th edition, 1874, on Arboriculture (vol. 1, p. 593) has

to say on the subject. "Arboriculture, or the cultivation of trees and shrubs, is one of the most interesting and important of the rural arts. It is a branch of industry which is daily becoming a subject of great national importance, not only as regards Britain, but also her Colonies and Indian Empire. Science has proved that the cultivation of trees and shrubs exercises a most benign influence on the climate, and on the health and death-rate of a country, as well as on its prosperity. Hence more attention is now being paid to the better conservation and management of forests, both at home and abroad. While agriculturists are continually carrying on a warfare of extermination with the straggling hedgerows of scattered trees that are yet common in many of the finest cultivated districts, they are fully alive to the importance of the shelter derived from trees when properly arranged on the exposed parts of their fields, or around their homesteads; whilst the profusion of trees and shrubs cultivated around suburban and villa residences, as well as in town squares and public parks, clearly shows how much agriculture is an object of delight and pleasure to the people. * * * * *

At no former period has the demand been so great as during the present century. Within that period the landscape of Great Britain has undergone a complete change, and many of her bleak and barren hills and waste lands are now covered by thriving plantations. Thus the adjoining lands have become more fertile and valuable, and the food production of the country has thereby greatly increased."

In Messrs. Chambers's Journal, part 153, Sept. 30th, 1876, will be found an essay "On the use of Forests," which may be cited as bearing direct testimony to the truth of the views maintained by myself. The author points out four distinct effects of forest vegetation on climate and rainfall, and shows how theory and experiment agree. The facts and reasoning employed in this paper would have been quoted in the text if they had fallen under my notice before it had been committed to the press.

No. 3 (*p.* 12).—*Water from Plants.*

We have the testimony of the late Commodore Goodenough to a similar fact in Figi. He says in his Journal (Dec. 10, 1873): "Walked up to the top of Ovalu. * * * It is not much over 2,000 feet, but very steep and rugged; in some places a climb hands and feet up the face of a rock. The foliage is beautiful as always. In one place a sort of strong creeper grows as thick as my wrist; one cuts off a foot of it, and on squeezing it out come several good mouthfuls of pure, clear water. At another place a lot of tall leaves collect water and carry it down the juicy stem of a tree which is, to look at, like a banana. One pierces the stem at the junction of the stalk of the big leaf, and

out comes a jet of pure water. The buds of the wild ginger hold water too, but not so much, and it has a decided taste. And all this is not in the ravines, but on the ridge along which we walked all the time." (p. 211).

No. 4—St. Vincent's.

The following tables of temperature and rain fall in St. Vincent's, during the period mentioned (at p. 18) from 1828 to 1829, were forwarded to me in 1835. They have never been published till now. With them came a memorandum which I here copy. "From the little variation of the temperature there is much deviation from the laws observed in more variable climates. Our plants are less affected by the seasons than by the soil, the elevation and the exposure, and are therefore developed without regularity The Demerara Indians are said to date the progress of their seasons from the flowering of certain plants, commonly known. I have before mentioned the fall of rain in St. Vincent; a journal of the Barometer would be of little interest. Its range on the coast is very trifling, and the column will remain for weeks without altering the convexity of the mercury. However, when taken to the summit of mountains it experiences very extensive changes, and accordingly I have been able with one of Dollond's instruments to measure our higher lands with all the necessary accuracy. On the coast of St. Vincent, the instrument rarely foretells anything but some violent hurricane."—[L. G., May 1, 1830.]

1823.

GENERAL ACCOUNT FOR THE PAST YEAR, 1823.

Month.	Thermometer.						Pluviameter.		Charaib Country	
	In Charaib Country.			In Kingstown.			Quantity of Rain, in inches.			
	Lowest at Sunrise.	Highest at Noon.	Average.	Lowest at Sunrise.	Highest at 2 p.m.	Monthly mean.	Kingstown.	Charaib Country.	Number of dry days.	Number of rainy days.
January	70	80	75	73½	82	78·68	3·36	3·27	19	12
February	74	80	76¾	75½	84	79·37	0·39	0·84	18	10
March	68	81	75	74	85	79·16	1·25	3·67	20	11
April	70	82	76½	74½	87	80·55	1·35½	7·50	18	12
May	75	83	77¼	76½	88	82·41	6·03	4·33	14	17
June	75	83	79	77½	87	82·31	7·33½	12·24	2	28
July	76	82	78	78½	86½	82·00	10·70	11·33	10	21
August	74	84	77½	78½	87½	82·54	4·57½	8·78	11	20
September	75	84	78½	79	88	82·83	7·66	6·31	8	22
October	75	84	80	76	88	83·07	4·01½	6·52	14	17
November	74	83	78½	76	86	80·78	16·75	14·29	8	22
December	71	82	76¾	75	86	79·52	5·56½	3·57	15	16
Year	73·08	82·33	77·39	76·20	86·25	81·10	68·99	82·65*	157	208

* The quantity of rain which fell in 1822 was 120·14 inches, being 37·49 inches more than last year. The number of wet days in 1822 were 261, and of dry days, 104.

1824.

General Account for the past Year, 1824,

Month.	Thermometer. In Charaib Country. Lowest at Sun-rise.	Highest at Noon.	Aver-age.	In Kingstown. Lowest at Sun-rise.	Highest at 2 p.m.	Monthly mean.	Pluviameter. Quantity of Rain, in inches. Kingstown. 1823.	Kingstown. 1824.	Charaib Country. 1823.	Charaib Country. 1824.	Charaib Country. Number of dry days.	Number of rainy days.
January	70	81	76¼	75	84	79·41	3·36½	3·81	3·27	2·88	18	13
February	74	81	77¾	74	85	79·29	0·39	3·04½	0·84	2·89	11	18
March	74	82	77¾	74	86	79·37	1·25	3·64¼	3·67	3·39	18	13
April	75	82	78	76	87	81·63	1·35½	2·72¾	7·50	2·70	16	14
May	74	82	77¾	76	86	81·14	6·03	10·07½	4·33	7·71	11	20
June	74	84	78	77	87	81·73	7·33½	13·19	12·24	10·82	9	21
July	76	84	78¾	77	86½	81·95	10·70	8·95½	11·33	9·61	10	21
August	76	84	79½	78½	88	82·44	4·57½	9·69½	8·78	13·11	8	23
September	82	80	81	79½	88½	83·53	7·66	6·24½	6·31	8·78	8	22
October	72	85	78¾	76	88	82·08	4·01½	11·95½	6·52	8·98	6	25
November	73	83	78	75	86½	81·43	16·75	6·58	14·29	7·05	10	20
December	68	84	77¼	73	85	79·23	5·56½	5·58	3·57	13·65	15	16
Year	74	82·66	78·23	75·91	86·46	81·10	66·99	85·50	82·65	91·57	140	226

1825.

Month.	Thermometer. In Kingstown. Lowest at Sun-rise.	Thermometer. In Kingstown. Highest at 2 P.M.	Thermometer. In Kingstown. Monthly mean.	Pluviameter. Quantity of Rain, in inches. In Kingstown. 1824.	Pluviameter. Quantity of Rain, in inches. In Kingstown. 1825.	Pluviameter. Quantity of Rain, in inches. At Langley Park. 1824.	Pluviameter. Quantity of Rain, in inches. At Langley Park. 1825.	Pluviameter. Quantity of Rain, in inches. At No. 14. 1825.	Charaib country. No. of dry days.	Charaib country. No. of rainy days.
January	75½	83½	80·17	3·81	3·18	2·88	4·15	4·52	14	17
February	75	86	79·98	3·04½	2·16	2·89	1·76	2·82	18	10
March	75½	88	81·37	3·64¼	3·87½	3·39	7·67	8·79	13	18
April	78½	89½	82·46	2·72¾	2·80	2·70	13·69	14·95	10	20
May	77	87½	83·12	10·07½	5·63	7·71	11·34	12·54	11	20
June	79	88½	82·80	10·19	10·13½	10·82	11·20	8·45	6	24
July	79	87	83·18	8·95½	5·35	9·61	4·83	5·84	13	18
August	78½	88½	83·82	9·69½	5·81	13·11	5·37	4·85	14	17
September	78½	88½	83·56	6·24½	9·61½	8·78	7·10	9·77	8	22
October	76½	88	83·02	11·95½	8·67	8·98	17·45†	16·70	8	23
November	77	87½	82·11	6·58	11·82	7·05	15·35	17·80	11	19
December	72*	85½	80·95	5·58	9·90	13·65	8·34	9·80	9	22
Year	76·83	87·5	82·21	82·50	78·94½	91·57	108·25	116·83	135	230

* On the 28th, being the lowest for many months. † 9·80 inches in one day alone, viz., the 11th October.

1826.

Month.	Thermometer. In Kingstown. Lowest at Sunrise.	Thermometer. In Kingstown. Highest at 2 P.M.	Thermometer. In Kingstown. Monthly mean.	Rain, in inches. In Kingstown. 1825.	Rain, in inches. In Kingstown. 1826.
January	76	87	81·70	3·18	6·06
February	74	84	78·90	2·16	7·26
March	70½	82	77·52	3·87½	4·01½
April	76	85½	80·08	2·80	1·51
May	77	87	82·02	5·63	3·08
June	77	86	81·78	10·13½	10·81
July	79	86½	81·86	5·35	7·54
August	77½	87	82·37	5·81	8·35
September	76½	88½	82·81	9·61½	8·96
October	78	87	82·56	8·67	7·33½
November	76	88	82·10	11·82	6·47½
December	76½	87	81·55	9·90	5·13
Year	76·17	86·29	81·27	78·94½	76·52½

* Lowest observation for some years.—Wind N.

1827.

Month.	Thermometer. In Kingstown. Lowest at Sunrise.	Thermometer. In Kingstown. Highest at 2 P.M.	Thermometer. In Kingstown. Monthly Mean.	Thermometer. In Kingstown. Mean, 1826.	Pluviameter. Quantity of Rain, in inches. In Kingstown. 1826.	Pluviameter. Quantity of Rain, in inches. In Kingstown. 1827.	Pluviameter. Quantity of Rain, in inches. In Charaib country. 1826.	Pluviameter. Quantity of Rain, in inches. In Charaib country. 1827.
January	73	86	80·21	81·70	6·06	4·11	7·84	4·42
February	75	85	79·56	78·90	7·26	3·70	6·14	3·93
March	75	86	80·35	77·52	4·01½	4·51	5·44	4·81
April	77	87	81·49	80·08	1·51	1·39½	2·09	2·41
May	78	86½	82·10	82·02	3·08	2·88	3·58	5·65
June	78	87	82·30	81·78	10·81	10·61	8·96	13·46
July	78	86½	82·05	81·86	7·54	15·89	7·26	12·08
August	77	87	81·93	82·37	8·35	14·14	7·55	15·50
September	78	88½	83·02	82·81	8·96	5·71	7·61	7·35
October*	78	88	82·02	82·56	7·33½	11·20	13·49	21·96
November	78	87½	82·45	82·10	6·47½	8·36	6·82	9·48
December	74	86	80·56	81·55	5·13	5·91	9·24	9·57
Year	76·58	86·75	81·50	81·27	76·52½	88·41½	86·02	108·62

The mean state of the Thermometer, at an elevation in the mountains, during the month of October, was 73·58; and the lowest observation taken there on any one day 65°, at sunrise on the 17th December; the highest at sunset, 77.

1828.

Month.	Thermometer.				Pluviameter.				Hygrometer.
	In Kingstown.				Quantity of Rain, in inches.				Kingstown.
					In Kingstown.		Charaib country.		
	Lowest.	Highest.	Monthly mean.	Mean, 1827.	1827.	1828.	1827.	1828.	1828.
January	74	84	79·09	80·21	4·11	4·18	4·42	2·10	...
February	74	84	78·49	79·56	3·70	3·23	3·93	4·50	...
March	71½	84½	79·41	80·35	4·51	1·38	4·81	2·61	42·88*
April	75	86½	80·63	81·49	1·39	4·08	2·41	5·82	42·00
May	76	87	82·34	82·10	2·88	4·67	5·65	7·85	44·41
June	77½	87	82·42	82·30	10·61	9·55	13·46	14·70	45·50
July	76½	88	82·12	82·05	15·89	7·97	12·08	6·62	44·79
August	77½	89½	83·60	81·39	14·14	6·96	15·50	6·74	44·76
September	78	89½	83·45	83·02	5·71	12·02	7·35	16·58	44·48
October	79	89	83·28	82·02	11·20	10·24	21·96	10·50	43·85
November	76	89	82·79	82·45	8·36	7·88	9·48	5·49	43·62
December	73	86	80·13	80·50	5·91	5·54	7·57	9·26	43·53
Year	75·66	87·00	81·48	81·50	188·41	77·70	108·62	92·77	43·68

* The lowest denotes dry, the highest moist weather.

1829.

Month.	Thermometer.				Pluviameter.				Hygrometer.	
	In Kingstown.				Quantity of Rain, in inches.				Average thereof in Kingstown.	
					In Kingstown.		Charaib Country.			
	Lowest.	Highest	Monthly mean.	Mean 1828.	1828.	1820.	1828.	1820.	1828.	1820.
January	71½	85	79·27	79·09	4·18	3·16	2·10	6·10	....	42·64
February	74½	84½	79·42	78·49	3·23	2·63	4·50	4·40	....	41·54
March	73½	87	80·32	79·41	1·38	1·18	2·61	1·10	42·88	40·91
April	77	86½	81·28	80·63	4·08	1·43	5·82	0·92	42·00	40·96
May	78	87	82·63	82·34	4·67	4·89	7·85	2·55	44·41	42·36
June	78	87	81·86	82·42	9·55	9·75	14·70	8·46	45·50	44·24
July	78	87	82·12	82·12	7·97	7·97	6·62	9·74	44·79	44·55
August	78½	88	82·71	83·60	6·96	8·05	6·74	8·08	44·76	44·90
September	77	90	83·66	83·45	12·02	3·40	16·58	5·52	44·48	44·12
October	78	90	83·26	83·28	10·24	8·15	10·50	6·16	43·85	44·12
November	77	88	81·93	82·79	7·88	7·03	5·49	7·69	43·62	44·16
December	75	87	80·03	80·13	5·54	7·51	9·26	7·56	43·53	44·32
Year	76·33	87·25	81·54	81·48	77·70	65·15	92·77	68·28	43·98	43·34

ABSTRACT of Monthly Means at Kingstown, St. Vincent's.

Year.	Temperature.	Rain in inches.
1823	81·10	68·990
1824	81·10	85·500
1825	82·21	78·945
1826	81·27	76·526
1827	81·50	88·415
1828	81·48	77·700
1829	81·54	65·150
Mean of seven years	81·45	77·31

N.B.—The above tables, which have been carefully copied from the originals, seem to contain some discrepancies; but as the variations between the given means and some of them, as deducible from calculation of the given figures, do not appear to differ very considerably, and as no check can now be put on them, and they can only be taken as approximations, they may yet serve to give a general idea of the climate, and as such they are here recorded.

No. 5 (*p.* 21).—*Wallaroo, S. Australia.*

"This is the barest, driest spot conceivable; since Valparaiso I have seen nothing so dry. There was once scrub and grass; now there is a relic of each, and much dust. All the timber having been taken off for fuel, for miles and miles, all is red-hot and dusty."—Commodore Goodenough's Journal, p. 263, Jan. 27, 1875.

No. 6 (*p.* 35.)—*Value of Forests.*

Mr. Ellwood Cooper, after pointing out how great climatic changes have taken place within the period of human history, in many eastern countries, once highly cultivated and densely peopled, but now arid wastes, and this "by the improvident acts of man in destroying the trees and plants which once clothed the surface and sheltered it from the sun and the winds"—goes on to point out that "in European countries, especially in Italy, Germany, Austria, and France, where the injuries resulting from the cutting off of timber have long since been realized, the attention of the Governments has been turned to this subject by the necessities of the case, and conservative measures have in many instances, been successfully applied, so that a supply of timber has been obtained by cultivation, and other benefits resulting from this measure have been realized." * * * *

"The preservation of forests is one of the first interests of society, and consequently one of the first duties of Government. All the wants of life are closely related to their preservation; agriculture, architecture, and almost all the industries seek

therein their aliment and resources, which nothing could replace. It is from thence that commerce finds the means of transportation and exchange, and that Governments claim the elements of their protection, their safety, and even their glory.

"It is not alone from the wealth which they offer by their working, under wise regulation, that we may judge of their utility. Their existence is of itself of incalculable benefit to the countries that possess them, as well as in the protection and feeding of the springs and rivers as in their prevention against the wasting away of the soil upon mountains, and in the beneficial and healthful influence which they exert upon the atmosphere.

Large forests deaden and break the force of heavy winds that beat out the seeds and injure the growth of plants; they form reservoirs of moisture; they shelter the soil of the fields; and upon the hill-sides, where the rain-waters, checked in their descent by the thousand obstacles they present by their roots and the trunks of trees, have time to filter into the soil and only find their way by slow degrees to the rivers, they regulate, in a certain degree, the flow of the waters and the hygrometrical condition of the atmosphere, and their destruction accordingly increases the duration of droughts, and gives rise to the injuries of inundations which denude the face of the mountains.

"The destruction of forests has often become to the country where this has happened a real calamity and a speedy cause of approaching decline and ruin. Their injury and reduction below the degree of present or future wants is among the misfortunes which we should provide against, and one of those errors which nothing can excuse, and which nothing but centuries of perseverance and privation can repair."

But there is another and a more cheering era in this history. This is when civilization has advanced, and man, under the safeguard of laws, sets about reforming the desolated forest.

* * * *

We must make the people familiar with the facts and the necessities of the case. It must come to be understood that a tree or a forest planted is an investment of capital. * * The great masses of our population and land-owners should be inspired with correct ideas as to the importance of planting and preserving trees, and taught the profits that may be derived from planting waste spots with timber, where nothing else will grow to advantage."

* * * *

The author then refers to statistical returns, and says that "In 1874, there was in the New England, Middle, and Western States, an average of thirty-three per cent. of wooded land. In

France and Germany it has been estimated that at least one-fifth of the land should be planted with forest trees, in order to maintain the proper hygrometric and electric equilibrium for successful farming. Mirabeau estimated that there should be retained in France thirty-two per cent. of land in wood. In the state of Texas, it is represented that there is an area four times that of the State of Pennsylvania, without a tree or a shrub. In California there is only four-one-tenth per cent. It is to *this* State I call your attention, and to *this* people my lecture is directed. We have, perhaps, the most healthful, most equable, the best climate on this globe, and the only objections that can be urged are the prevailing high winds, and an uncertain, as well as an insufficiency of rainfall. Moderate the winds, increase the rain, and we have perfection."

* * * *

"How is this to be done? How are we to obtain this result? By planting forest trees."

* * * *

"It is known and proved that the three-fourths of the surface will produce more, if protected by trees planted on the other fourth, than the whole would without the trees and without the protection."

Here we have the opinion of a man well able to judge, and who appeals to statistics to confirm his views. What would be his opinion of a people who are found destroying some of the most valuable of the timber in any given country, without provision for the re-production of forest vegetation—sacrificing, as is the case in Australia, acres of such trees as the ironbark, white and blue gum, and other valuable ornaments of the country—and without regard to the wants of the present or future settlers, under the plea that it is advantageous to have a little more grass, and without considering others are coming after them, who have rights of which no individual is justified in depriving them.

Mr. Cooper adds to his arguments this—"What we have, therefore, to do as individuals, is to begin at once to plant. It is an obligation we owe to the possessory title to land; and financially we will be rewarded for our labours."

(*No. 7.*)—*Forest Vegetation on the Coast.*

The following extract from a letter to myself, under date of 16th November, 1876, by a friend whose powers and habits of observation are of a high order, and to whom our Society is indebted for a valuable communication on the connection of forest vegetation with geology, is worthy of consideration by those who doubt the influence of trees upon the atmosphere. "The effects of forest vegetation on climate are most marked in the Coast district, about the heads of the Macleay, Bellinger,

and Clarence Rivers, where dense scrubs containing very large trees occur. In those localities it is almost continually raining. About three years ago I made a survey of one of the heads of the Clarence River and the watershed between that river and the Macleay, and was five weeks in the scrub region. During the whole of that time, although the inhabitants there told me the weather was no wetter than usual, there were only four days in in which we were not drenched to the skin. That the weather was in its ordinary state was proved by the colour of the water in the streams, which, although copious, was not turbid, as it would have been if they had been in fresh. But in the more open country, twenty or thirty miles inland from those localities, the rainfall is not nearly one-half. This must be owing to the dense vegetation a great deal more than to the fact that the steep and high escarpment forming the edge of the table-land catches the rain-clouds: for when on the top of Point Look-out (5,100 feet high, by aneroid) the sun was shining on us, whilst we could distinctly see the rain pouring in torrents several hundred feet below, and though the place on which the rain was falling was not half-a-mile away, it was more than twenty minutes before it reached the peak. It travelled *upwards*, and it was quite as interesting to watch its approach as it was unpleasant when it arrived."

(*No.* 8.)—*Forest Protection in the Sandwich Islands.*

To complete the evidence from all parts of the globe, the following extract from the *Hawaiian Gazette* published at Honolulu, 13 Sept., 1876, is appended:—

"A Bill has passed the Assembly which at first sight may be thought to be a step in the direction of forest preservation and increase;—a measure for want of which the Islands have been suffering for many years, and will, we fear, continue to suffer as long as the present indifference on this subject continues.

"What is wanted here is a system of forest culture and conservation similar to those which various European nations have found themselves forced to adopt or forfeit their national existence. We must adopt a system whose corner-stone is the axiom, 'The greatest good to the greatest number.' If history, and experience, and science have thoroughly demonstrated any one thing in the world of material things, it is that forests are as necessary to the life of a land as lungs are to the life of the animal. When a land is shorn of its forests, its green fields become barren wastes, its rivers become dry in summer, and raging, destructive torrents in winter. Its inhabitants diminish in numbers, and it finally becomes a desert, fit only for the abode of owls and bats.

"This dismal condition is undoubtedly in store for us unless we avert it by prompt and energetic action. And no half-way measures will suffice. If we would make sure of success we must boldly inaugurate a system which will in all probability meet with strong opposition from real-estate owners;—a system which may be regarded by the few as a violation of personal rights, but which nevertheless must be enforced in the interests of the many. There should be a Forester-in-chief appointed for the whole country, whose business it shall be to supervise and direct the operations of the Bureau.

"Every man owning ten acres or more of land should be compelled to devote one-half of his land to the cultivation of trees, and all forests now existing should be maintained in vigorous health and growth, and their limits gradually increased year by year.

"Since the above was written, we notice an article on the same subject in the *Advertiser*, from the pen of Mr. Gibson, which presents some new ideas on this subject, worthy of consideration."

Discussion.

Mr. Charles Moore (Director of the Botanic Gardens) said they were much indebted to their Vice-President for this elaborate paper. It was a subject on which he (Mr. Moore) had thought a good deal. There were difficulties in the way of a general conclusion, so far as Australia was concerned, which he could not get over. He had been a resident in this Colony for nearly thirty years, and knew the vegetation of it better perhaps than any other living man. He had known about Wollongong what he might call a "jungle vegetation"—a vegetation with dense undergrowth, producing palms and tree ferns of enormous size. That extended from about 60 or 70 miles south to the extreme north; and was generally produced on the Coast Range. That was the kind of vegetation spoken of as inducing moisture and holding moisture.

But the whole of that vegetation had been nearly destroyed. The patch Mr. Clarke referred to at Wollongong was very beautiful. Three years ago, he (Mr. Moore) made notes of every plant there.

It was a notorious fact that the dense vegetation of this country had been almost wholly destroyed. In addition to the effects of ring-barking and other known causes, whole tracts had been destroyed without any apparent cause; perhaps from a root disease. It would follow from this, on Mr. Clarke's theory, that the climate must have become drier. But he (Mr. Moore) ventured to say the climate had not become drier. There was no apparent effect, except that where rivulets were formerly almost continually running they were dried up. The large rivers had not been affected. He spoke of Wingecarribbee. There, fourteen years ago, all the rivulets were running; a few years ago all these rivulets were dry. So with Illawarra. A few years ago nothing in the world was more beautiful than the forest vegetation and rivulets of Illawarra: now many of the rivulets were dry.

Now the main rivers of the Colony contain as much water as at any time within our knowledge. They did not find that where they destroyed forests they created deserts. They had grass; and that presented almost as great a surface to catch moisture as the trees did. With regard to stories about trees producing water, he thought they were fictitious. There was, indeed, a night-breathing or perspiration of plants. But about trees "weeping" he had much doubt. His predecessor, when lost for three weeks, between Moreton Bay and Gayndah, kept himself alive by sucking the moss of a climber. The pitcher-plant contains water, but that is distilled.

Within the last thirty years a vast extent of country has been cleared, and the climate has not been affected by it. Generally the rivers have as much water as ever. In the South of Europe they have sown the seeds of pine-trees, and the effect has been to dry up the former moisture. As for marshy places, undoubtedly the treading of cattle causes them to dry up. The lagoon at Wollongong has been thus dried up. It would be right for the Government to protect these places.

Rev. W. B. Clarke said many of our rivers had not yet been cleared of timber. The Murray, and other rivers had never been cleared at the heads of them. But the system of ring-barking was the most serious part of the question. As to the amount of water, no data existed as to what it was thirty years ago; but floods are recorded to have exceeded those of the present time.

[The debate was then adjourned to the next monthly meeting of the Society.]

The discussion on the Rev. W. B. Clarke's paper entitled "Effects of Forest Vegetation on Climate" was resumed, 6 Dec., 1876.

Mr. C. Moore restated the points he had previously advanced, as follows:—1. "That the dense jungle vegetation, which of all others is supposed to attract and hold moisture, and which for about 400 miles was so general within the coast range, has been almost wholly destroyed during the last thirty years. 2. That in addition to this, millions of acres of more open forest have been destroyed during the same period. 3. That, notwithstanding this tremendous destruction of trees, no drier climatic effect has been experienced. 4. So far as my knowledge extends, the only observable effect has been that in some districts in which the forest has been destroyed small rivulets usually contained water, but in many instances are now dry. 5. That now the larger rivers of the Colony show no diminution in breadth or depth. 6. That the rainfall, instead of decreasing, as might have been expected from the destruction of so much forest, has been of late years more regular and greater than formerly.

Mr. W. A. Brodribb complimented the writer of the paper on his able performance, and agreed with him on the main points he brought forward. It was most necessary that our useful timber should be preserved by legislation. The red gum was being destroyed on the rivers. Then there was the pine, in the Riverine country, valuable for buildings and fences, that should be preserved; and there were the stringybark, the cedar, and various other timbers that should be protected. He considered though that our scientific gentlemen made a mistake in drawing comparisons between the forests in the southern and northern hemispheres. The forests in the northern hemisphere shed their leaves to the depth of twelve or eighteen inches, which formed a

manure that supported the trees in spring. In the southern hemisphere the forests took everything out of the ground and gave nothing to it. He was not opposed to barking the trees to get rid of those that were useless. Much of the forests of Australia was totally useless. What a wretched forest there was on the road to Bowenfels—perfectly useless to man and beast. If it could be removed and English trees planted, there would be a far different state of things in the locality, as the timber which absorbed the moisture that fell from the heavens would be away.

Dr. Neild read from a report by Mr. Fryar, an owner of estates in Antigua, upon the effects of forest destruction in the island of Mauritius. The effect of the destruction of forests in a tropical island like Mauritius would be followed, the writer stated, by a decrease of humidity, an elevation of temperature, and a diminution in the rainfall.

Mr. Dixon stated his experience after a residence of seventeen months on Maldon Island, in the Pacific. No rain fell on the island during that time, though rain could be seen falling to the north and to the south; and as soon as clouds came over the island they disappeared. At one time the island was inhabited, and must have had forests upon it; but while he was there only two or three small patches of trees existed, and it was evident that the scarcity of timber caused a want of rain.

The Rev. W. Scott explained that clouds over-saturated with moisture passing over a dry island like the one mentioned would be no longer over-saturated when they met with the heated air rising from the island, and therefore no rain would fall; but when the clouds passed beyond the island they might meet with a cooler current of air, and, again becoming over-saturated, rain would fall.

The Chairman replied to the points advanced by Mr. Moore, and challenged him to produce data in support of his 5th and 6th propositions now brought before the meeting. He referred to the letters from Mr. De Salis which appeared in the *Herald*, and, proceeding, said:—I cannot see that in characterising ring-barking as it has been practised in these Colonies as I did, and do, I have anything to retract. Mr. De Salis admits in his second letter "that ring-barking worthless scrub is the legitimate use of ring-barking, but to ring-bark a forest of well-grown or well-growing trees is its abuse." If this were all that I intended, we might have, doubtless, been spared the necessity of alluding to the practice at all. I maintain, however, that "well-grown and well-growing trees" that are not "useless scrub," have been ring-barked in various parts of the country to a great extent—and that some of the most useful and valuable timber trees have been ruthlessly killed, and it was to this wanton use of the axe

I objected, and do still object. About ten days ago, I asked a fencer of great experience, who was then putting up a fence more than a hundred miles from Sydney, whether he had ever known "ironbark trees to be ring-barked," and his reply was, "hundreds of acres of that and other valuable timber." And I know from other sources to which I have applied for information, in the desire to find out if I had in any way misstated the fact, that such timber is still being ring-barked. My first objection to ring-barking is, that it is a practice of a slovenly and a greedy kind, and is adopted to save the expense of clearing and stumping the ground. It is what, to use the language once heard in the British Parliament, is merely a "breeches pocket" policy, though some think it is of national advantage to keep a few pounds in, or to add a few pounds to the purse of an individual, without reference to future conditions or the claims of posterity, and this is the only argument yet advanced to us to justify the practice. I give these gentlemen full credit for their patriotic determination to do what they can for the good of their adopted country, and I hope we are all, even the un-acred members of this Society, aiming in our respective occupations at the same end. Nor have I denied that if a dead tree does allow more grass to grow than a living one, some advantage for a time may be gained; but when the dead tree decays and scatters its branches over more ground than it covered before, would that be an advantage or a disadvantage? And must not that eventually be the case, and so injury be done to the future occupant, or free selector who is now, by law, entitled to all the advantages of occupancy? It is very well to talk of "worthless scrub on dry ranges"; but what is to be said respecting full, well-grown, useful timber on plains or gently undulating ground? I am challenged to "figures," which are to convert "theory into science." Now, as I have before said, the figures are only to be found in the possession of those who profit by them, and so the science of the question cannot be submitted as a sum in addition or subtraction; it must therefore rest on other experiences, and as yet we have no data to appeal to beyond the experience of persons in all other parts of the world, and to those I have already appealed. There are no published data in this Colony as to the advantages even alleged to have been gained by ring-barking of worthless "scrub on dry ranges." Figures founded on unknown data or on imperfect premises may prove anything or nothing, and have not even the value of the theory which is said to be founded on "five columns" of what has been called "inconclusive quotations." I repeat, let "all the figures be imported, as well as the momentary profits" of ring-barking. This is for the assertor of those profits to do. And till this has been done the figures have only a one-sided value. But the other

side of the ledger must be filled in (till the data have been produced) by experiences—and in such case the experience of the whole world, I may say, is no mean representative. This, therefore, represents what I have to say against the injudicious destruction of forest vegetation. And if it be not enough to satisfy commercial interests, it ought at least to satisfy common sense and unbiased judgment. "The facetiæ as to creating water" are founded on what I would not like to call ignorance of physics, but certainly on a want of recollection. What is rain—what is snow—what is hail—what is fog—what, dew? All are but various forms of precipitated or condensed vapour; nor can that vapour become or be created rain till the vapour has been subjected to some process, visible or invisible, by which the atmosphere which holds the vapour has by some agency been forced to part with it. If forests act as an agency of the kind, he who plants trees or preserves trees, capable of performing any portion of this agency, is a creator of water; and however ridiculous it it may seem to a sceptical opponent, reason will teach us that if the statements I have quoted are reliable, "forest vegetation" is an agency in "creating water." I have quoted the case of Ascension Island in the midst of the Atlantic Ocean, as well as other oceanic islands, in order to show how, even in the midst of the ocean itself, rain ceased when vegetation was destroyed, or passed suspended as vapour over the speck of land, and that it again resumed its fall when re-plantation had taken place, and singularly enough some of the chief plants introduced to effect this return to former deposition of moisture were our Australian wattles. In this instance, at least, trees were condensers of vapour on a mere speck of land surrounded by the ocean waters, which refused to contribute to a naked surface. Similar instances occur even on the edge of or within a desert, and the report of Vice-Consul Dupuis to the British Government on the condition of the desert country in the neighbourhood of Tunis may be referred to in confirmation. We are told what Elihu Burritt says of the loss of £8,000 by allowing one hedge oak tree to stand (when perhaps according to some, it ought to have been ring-barked or better cut down). But does any one in his senses believe that that tree did not spread moisture around it, keep vegetation greener in the vicinity, suck up nutriment, or supply it to deep strata, and shed its leaves to nourish the soil? It may have been three centuries before the farmer took up his land, and if he preferred the handful of grass that could grow where it stood, he might, in all probability, have found space enough elsewhere in some unoccupied patch of ground on his farm for a similar quantity. If an oak by its roots carries down moisture to deep cracks in the underlying strata, and so adds to springs; or, if even a gum-tree, whose roots run along just below the surface, do

the same to a less extent, they, each in its own way, contribute to the general growth of other kinds of vegetation; and we have instances enough in Australia of the effects of even an ordinary drought on pastures to bid us be cautious how we rashly cut away all chance of nourishment so produced from the roots of grasses themselves. We all know how long it takes to revive pastures that have once been scorched into a state near to destruction. I am given to understand that Mr. Brodribb himself, and his relation Mr. Desailly, in Victoria, had sad experience of it. Can we believe that the dead roots of trees are more available for such a process than living roots, or that the whole order of nature does not show that it was the will of the Creator that the earth should be replenished by arboriculture and agriculture as well as by the culture of grasses, seeing that trees and grasses all came in together in the same natural epoch, and have ever since thriven together in harmonious union? To suppose a continuance of this does not imply the neglect of judicious clearing of land—ring-barking does not clear it—and some land must be cleared, if the hoped for influx of population should take place. But, unless men be contented to live without the shelter and other benefits of trees, and will not provide them where needed by fresh plantations, they can only inhabit, like the nomadic races, a half-desert region, where there may be only dry river beds and wells that hold no water. I would ask those who are doubtful, to carefully peruse the documents from which I have quoted in my original paper, and to weigh well the words of a writer in a late number of *Chambers's Journal*:—"Whilst extensive forest clearings have been made, reckless of consequences, in India, the United States, and other portions of the globe, France was the first country to awake to the folly of the system. The old seigneurs loved woods; the peasant farmer hates them. In the south, where the land has been more cut up into small properties than in other parts, the trees have been so cleared off that there are whole communes without any—mountain communes, which, owing to the now unchecked action of the rains, bid fair to be nothing but bare rock. The peasant grubs up a tree, and thereby gets a few more square yards for his rye or lucerne; but also he helps to keep off the gentle rains, and to bring about destructive droughts, alternately with no less destructive floods. That, at any rate, was the conclusion to which years of study and observation led M. Becquerel, who, a quarter of a century ago, published his book on the Effects of Forests on Climate." (30th September, 1876, p. 591.) I may add that I very much regret never having seen M. Becquerel's work, as I doubt not I could have found in it many corroborations, as strong as that last quoted, of the justness of the views which I have now endeavoured to enforce and illustrate. Lastly, to meet an argument which I have heard in favour of ring-barking and clearing

on account of the saving of moisture for the lesser vegetation, I will venture, in a final brief extract, to refute it in the words of the same writer in *Chambers's Journal*, just referred to. "Of course, since rain comes, because the air is too cool to hold its moisture any longer in solution, there ought to be more rain in a wooded than in a treeless district; and so there is, from 6 to 8 per cent., as M. Faudrat found by putting up several rain-gauges, some in a forest seven yards above the tree-tops, others on treeless ground, some two hundred yards off. . . . It may be said if the trees bring more rain, they use up more than the treeless ground, for their roots drain the soil, and their leaves drain the atmosphere. Not so; though wood is more than half water, the amount of water contained in all the wood in a forest is the veriest trifle compared with the rain that falls on it during a year. Moreover, a series of experiments seems to show that the amount of water decomposed by an acre of forest is very much less than that required by an acre of cabbage, or wheat, or clover. Again, because pines and other trees (notably the blue gum, *Eucalyptus globulus*, which is being planted by the million in Algeria) dry up marshes, it has been argued that trees must lessen the water supply. But here again experiment comes in and proves that this drying up is not due to evaporation through the leaves or to the water being in any other way sucked up by the trees. All the trees that have this property can and do thrive also in hungry soils; they drain the soil by virtue of their spreading roots, which enable the water to run into the lower strata, and this meets the observation of my friend Mr. Brodribb (whom I am glad to meet here to-night after twenty-five years' acquaintance, as a member of our Society), that the trees on the road to Bowenfells are perfectly useless to man and beast—for they are not perfectly useless in another way, as they supply water to the deep creeks which are the feeders of the Nepean and Hawkesbury. If any further argument is required, it may be well to refer to the experiments carried on in France during the last twelve years, and to leave opponents to be refuted as the Directors and Inspectors of Forests refuted the misunderstandings of Louis Napoleon and M. Fould.

But if gum-trees, as well as others, produce accession of water to the earth below, is it not suicidal to ring-bark trees, destroying the capacity to do what nature demands? If trees are to do what experiment suggests, and what ring-barking indiscriminately carried on altogether prevents, will it not hereafter be found to be folly, when too late, whatever the temporary profits be at the moment? Lastly, I would ask why in the neighbourhood of ring-barked areas the natural forestry loses its vigour, and appears to suffer from a want of nourishment?

FOSSILIFEROUS SILICEOUS DEPOSIT FROM THE RICHMOND RIVER, N.S.W.

By Archibald Liversidge, Professor of Geology and Mineralogy in the University of Sydney.

[*Read before the Royal Society of N.S.W.*, 6 *December*, 1876.]

Most of the specimens of this material which I have had the opportunity to examine, exhibit many of the appearances which are usually presented by the deposits thrown down from hot springs or geysers.

Although no such hot springs or geysers are known to exist at the present day in the Colony, yet I understand from Mr. W. Wilson, of Monaltrie, to whom I am indebted for my specimens, that the district in which they occur presents many features which lead him to consider that it has been the scene of comparatively recent (*i.e.* in a geological sense) active volcanic phenomena.

The district has not, I believe, been examined in detail by any trained and experienced geologist; but judging from Mr. Wilson's account it must be one of remarkable interest.

Basaltic and trachytic rocks are the principal surface rocks occurring in the neighbourhood. The basalt is remarkable for containing very large and well developed amygdaloids of chalcedony, agate, arragonite, and certain of the commoner zeolites. Of the amygdaloidal and other minerals, together with specimens of the matrices, Mr. Wilson sent a large series to the Commissioners for the Philadelphia Centennial Exhibition—the collection of which must have entailed the expenditure of much time and labour.

In the interior of the mass, the siliceous deposit is usually of a more or less pale wax colour, and in certain respects closely resembles *wood opal.* Wood opal is actually present, and in parts streaks of true opal, although not of the precious variety, occur. Occasionally, on breaking open a specimen, jet-black patches are met with; the colouring matter apparently contains carbon, as it is slowly burnt off in the blow-pipe flame.

On the surface, the mineral weathers white, and the decomposition passes in to a depth of from $\frac{1}{4}$ to $\frac{1}{8}$ inch.

Chemical Analysis.

Weathered portion.

Moisture, given off at 100°	4·16
Combined water (loss on ignition) ...	1·78
Insoluble silica...	89·74
Soluble silica	·47
Alumina and iron sesquioxide ...	1·13
Lime	·48
Magnesia	1·98
Loss	·26
	100·00

Specific gravity, 2·046 at 66° Fah.
Adheres strongly to the tongue.

Unweathered portion.

Water, given off at 100°	4·08
Combined water (loss on ignition) ...	·48
Insoluble silica...	91·67
Soluble silica	·30
Alumina and iron sesquioxide ...	1·56
Lime	·36
Magnesia	·55
Loss	·90
	100·00

Specific gravity, 2·330 at 66° Fah.

The composition shows that it answers to the common siliceous sinters or geyser deposits.

It will be seen that the weathered specimen has a lower specific gravity, and contains rather more water, also more lime and magnesia.

In places the structure is more or less distinctly lamellar, evidently due to the manner of its deposition is successive layers. The fracture is more or less distinctly conchoidal across the planes of deposition, but where the lamellar structure is less strongly marked or altogether obliterated, the fracture is conchoidal in all directions.

The weathered surface is usually marked with the remains of ferns, which stand well out in relief; with the ferns and stems are the fruits and seeds of other forms of vegetable life.

Within the substance of the mass occasional layers of a brilliant white colour are met with, and along these layers it splits into flakes and slabs with more or less ease; these white

LIVERSIDGEA

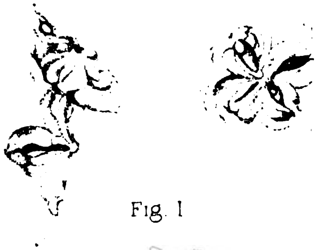

Fig. I

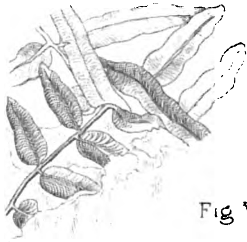

Fig VI

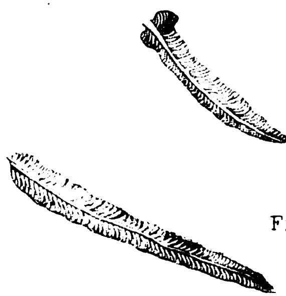

Fig VII

Fig V

Fig II

Fig. III

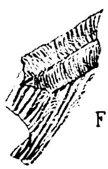

Fig VIII

Fig IV

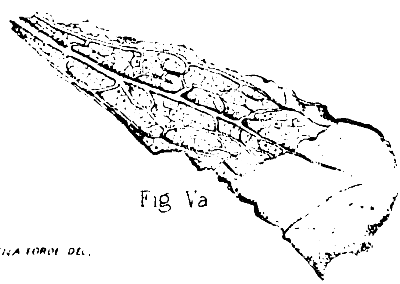

Fig Va

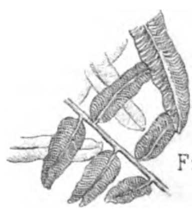

Fig. IX

HELENA FORDE DEL.

S.T. LEIGH & Co LITH.

LIVERSIDGEA OXYSPORA

I Fruit Nat. size
II & V Seed Magnified 5 times
III Seed Nat size
IV Leaf " "
Va Leaf Magn 5 times

layers are much softer than the other portions, and they are found to be composed almost exclusively of the casts of vegetable tissue; the fern fronds and stems are especially well preserved. Also scattered irregularly through these layers and the solid substance of the mineral, the remains of certain fruits and seeds are met with.

These latter were submitted to the Baron von Müller, C.M.G., M.D., F.R.S., the highest authority upon Australian Botany, who at once pronounced them to belong to a new genus; I now beg to append his description, and at the same time to tender to him my best thanks for his ever ready assistance in all questions relating to botanical matters.

Description of Fossil Fruits in Siliceous Deposit, Richmond River. By the Baron Von Müller, M.D., C.M.G., F.R.S.

LIVERSIDGEA.

Fruit divided into four (or perhaps more) turgid lobes; each division outward free and dorsally rounded, the cells filled with a plicate substance.

Placentas parietal. Seeds several (or perhaps many) imbedded in the folds of the inner substance, turgid-oval towards the one extremity, thence gradually attenuated to the almost pungent point of attachment. Testa thin and pale; nucleus very smooth and shining; chalaza somewhat lateral, close to the turgid extremity of the seed, rather large, orbicular-oval.

Liversidgea oxyspora.

Diameter of fruit ¾ to nearly 1 inch. Seeds from 2 to 3 lines long, the inner portion homogeneous from infiltration of silicic acid, with no trace of original cotyledonar division, hence the embryo probably minute, within a copious and equable albumen.

In tracing the affinity of this vegetable relic, we are reminded as well of the aurantiaceous tribe of *Rutaceæ* as of *Guttiferæ*, from both of which the exterior placentation would already separate it, while by this the alliance to *Capparideæ* and *Bixaceæ* is indicated, but from the material hitherto obtained the precise ordinal position of this new generic type dedicated to the learned discoverer cannot yet be affirmed.

The form of the seed is remarkable, and gave rise to the specific name.

There is one impression of a leaf with these fruits, and this leaf probably belongs to the plant the fruits of which are now described.

See plate, figures I to V. Figures VI to IX represent the ferns accompanying the fossil fruits.

The so-called Meerschaum from the Richmond River, N.S.W.

I take this opportunity to mention also that there is a deposit of very white and porous hydrous silicate of alumina on this river, which has often been sent down to Sydney as meerschaum. Probably this is partly due to its low specific gravity, for when first immersed it floats upon water. It is sometimes said to contain leaf impressions; colour, dead white; breaks with more or less well-marked conchoidal fracture; shows traces of stratification; very porous, and adheres strongly to the tongue; H = about 2; can be scratched by the thumb-nail, and leaves a mark on cloth, but not readily.

Sp. gr. after immersion in water for some time = 1·168. Before the blowpipe blackens slightly at first, and becomes harder after ignition; it is infusible, and yields a blue mass when ignited after moistening with cobalt nitrate; this at once distinguishes it from meerschaum, which would under those circumstances afford a pale pink-coloured mass.

Analysis.

Water, given off at 100°	3·28
Combined water (loss on ignition) ...	4·34
Insoluble silica...	51·35
Soluble silica	·11
Alumina	37·72
Iron sesquioxide	·46
Lime	·34
Magnesia	1·25
Alkalies...	traces
Carbonic acid	1·54
	100·39

The low specific gravity is a most remarkable characteristic of this mineral, but in other respects it answers to *cimolite*, the *κιμωλια* of Theophrastus.

[Plate.]

ON A REMARKABLE EXAMPLE OF CONTORTED SLATE.

By Archibald Liversidge, Professor of Geology and Mineralogy in the University of Sydney.

[*Read before the Royal Society of N.S.W.*, 6 *December*, 1876.]

The specimen of more or less imperfect slate which I now have the pleasure to lay before the Society is, I think, a most remarkable example of true contortion, accompanied by slaty cleavage, but contortion on such an extremely small scale that it in certain aspects appears to resemble the well-known cone-in-cone structure seen in coal and many rocks.

The specimen was obtained by Mr. Fielder from the Peelwood Copper Mine, near Tuena. Mr. Fielder succeeded in detaching this most interesting and beautiful example from a projecting point of weathered rock, but only after the expenditure of much time and trouble, for the slaty rock was far too tough, and also too fissile, to admit of its being broken off in large blocks by blows from a hammer or pick, so he had to saw it off—a very tedious and laborious operation.

It will be equally observable in the specimen and the photographs which I lay before you, that some of the plications are not more than, even if so much as, an eighth of an inch across, whilst the widest of them do not exceed two inches, and the depth of the largest cleavage plane in the specimen barely reaches three inches; its extent in the direction of from before backward I have no means of telling, as the specimen sawn off had a thickness of but about two inches. The dark lines *l*, *m*, *n*, and *u*, *v*, in plate II, represent fractures in the specimen, and their plications beautifully indicate the cleavage planes to which they are parallel. Whether the cleavage planes extend over any length of country I do not know, as I have not visited the locality whence the block was brought, neither have I been able to obtain particulars on this point. The contortion is probably of quite a local character, as it does not appear to have been noticed elsewhere in the district.

The rock or slate has the appearance of the grey killas of Devon and Cornwall; it is in all probability of Devonian age.

As I have before mentioned, the specimen has somewhat the appearance of the familiar cone-in-cone structure (see figures, two-thirds of natural size—No. I shows the weathered surface, and No. II a smooth and imperfectly polished one). The surface, which has been carefully rubbed down and smoothed, presents a series of alternating light and dark bands, similar to the banded or ribboned appearance exhibited by a well-kept English lawn cut by a mowing machine which has been worked in lines alternately up and down the length of the lawn.

This banded effect is due to the manner in which the light is reflected from the cut edge of the cleavage planes. When held in one position the smooth surface presents a fairly uniform grey tint, but at a certain angle to the light it appears to be made up of alternate light and dark bands, and when reversed in position the light bands become the dark ones and *vice versâ*.

Thus, in one position the bands *a*, *b*, *c*, *d*, *e*, *f*, *g*, *h*, *i*, *j*, appear light grey, but when the specimen is turned upside down they exhibit a dark grey shade.

Even if subsequent examination made on the spot should prove this to be a case of cone-in-cone structure, the specimen will still, I think, be of equal value and interest.

The chemical composition of the slate is as follows:—

Analysis.

Hygroscopic moisture	...00·48		
Combined water (by difference)	... 3·37	... ...	3·85
Silica	... ·22		
Alumina	... 3·63		
Ferric oxide	... 4·47		
Lime	... ·19	Soluble in acid ...	10·51
Magnesia	traces		
Soda	... 1·16		
Potash	... ·84		
Silica	...67·64		
Alumina	...16·77	Insoluble in acid...	85·64
Ferric oxide	... 1·23		
			100·00

Sp. gr. = 2·75, given by small fragments which had been immersed in water for some time, at 75° F.

[Two plates.]

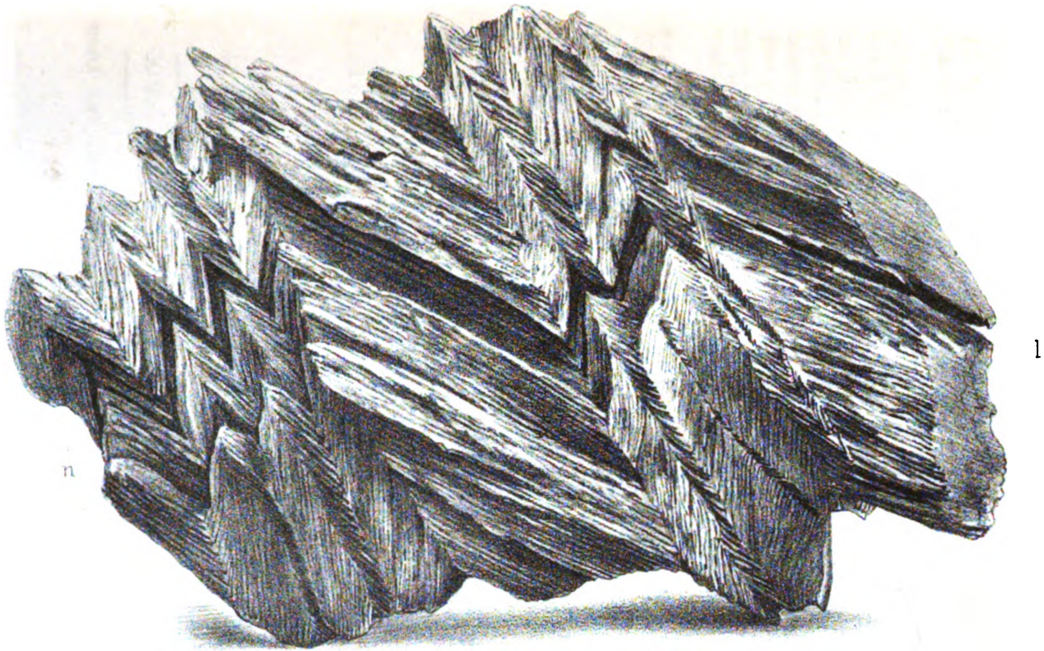

Fig. I.
CONTORTED SLATE (Peelwood, N.S.W.)
Weathered Surface.
⅔ Nat. Size)

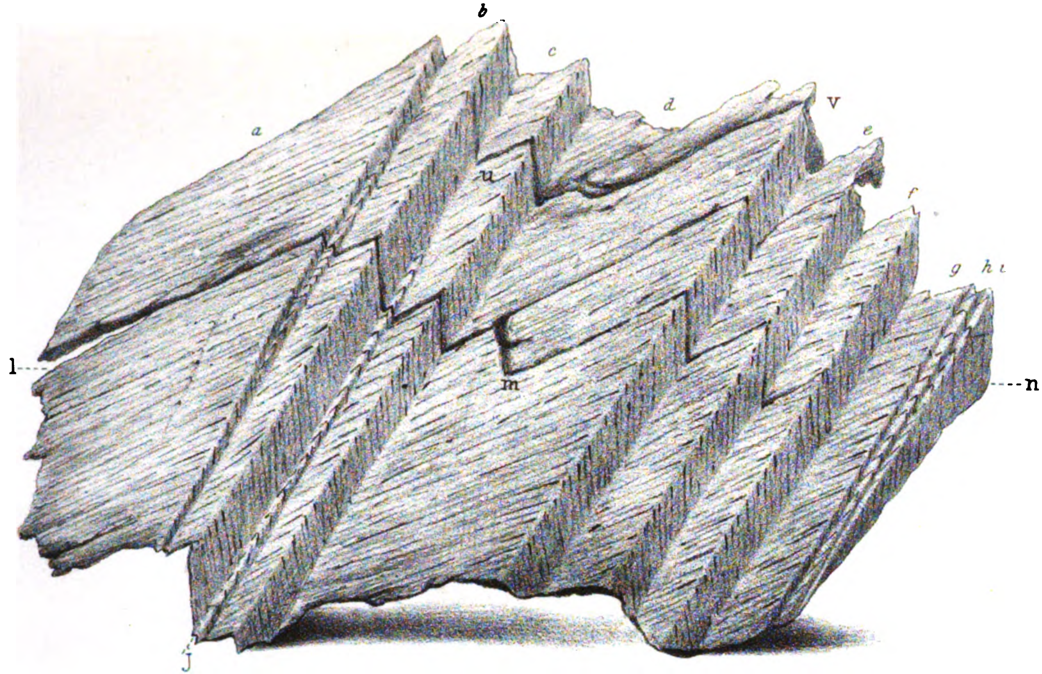

Fig. II.

CONTORTED SLATE (Peelwood, N.S.W.)

Polished Surface.

⅔ Nat. Size

A. Liversidge Direx.t

S.T. Leigh & C.o lith Sydney

PROCEEDINGS.

PROCEEDINGS

OF THE

ROYAL SOCIETY OF NEW SOUTH WALES.

WEDNESDAY, 3RD MAY, 1876.

The annual *conversazione* was held in the Masonic Hall; many interesting and valuable examples of optical, electrical, and pneumatic apparatus; geological and other collections; maps, photographs, rare prints, books, and other objects were exhibited by various members of the Society.

The exhibits, many of which were microscopes, bordered close upon one hundred in number.

Including the members and their friends, the number of guests amounted to nearly four hundred.

WEDNESDAY, 17TH MAY, 1876.

Ordinary monthly meeting of the Royal Society of New South Wales, held in the Society's Rooms, Elizabeth-street.

The Rev. W. B. CLARKE, V.P., in the Chair.

The minutes of the last meeting were read and confirmed.

The following gentlemen were duly elected ordinary members of the Society:—

Francis Henry Wilson, Union Club.
John Usher Cox Colyer, A.S.N. Co., Sydney.
Percy Williams.
Cecil West Darley, Newcastle.
Arthur Dight, Richmond.

Seventeen new candidates were proposed and seconded.

The meeting then balloted for the officers for the ensuing year, and the following gentlemen were duly elected, viz. :—

PRESIDENT
(ex officio) :

HIS EXCELLENCY SIR HERCULES ROBINSON, K.C.M.G., &c., &c., &c.

VICE-PRESIDENTS:
REV. W. B. CLARKE, M.A., F.R.S., F.G.S.
H. C. RUSSELL, B.A., F.R.A.S.

HONORARY TREASURER:
REV. W. SCOTT, M.A.

HONORARY SECRETARIES:
PROFESSOR LIVERSIDGE. DR. ADOLPH LEIBIUS.

COUNCIL:

LORD, THE HON. F., M.L.C.	ROLLESTON, CHRISTOPHER.
MANNING, JAMES.	SMITH, THE HON. J., M.D., LL.D.
MOORE, CHARLES, F.L.S.	WRIGHT, H. G. A., M.R.C.S.

The Honorary Treasurer read the following Financial Statement for the year ending 30th April, 1876 :—

RECEIPTS.

	£	s.	d.
To Balance in the Union Bank on the 30th April, 1875	£ 90	0	0
„ Subscriptions and Entrance Fees	222	11	0
	£312	11	0

DISBURSEMENTS.

	£	s.	d.
By Rent of Rooms from 1st May to 31st January, 1876	£ 37	10	0
„ Office Keeper (Mrs. Casey)	8	0	0
„ Office furniture and effects	64	16	6
„ Refreshments for monthly meetings	10	16	7
„ Stationery and Printing Account	27	1	0
„ Advertisements	8	8	6
„ Postage and Petty Cash Account	17	2	1
„ Assistant Secretary's salary from 1st Jan. to 31st Dec., 1875	40	0	0
„ Balance in the Union Bank on 30th April, 1876	98	16	4
	£312	11	0

ASSETS.

	£	s.	d.
To Balance in the Union Bank	£ 98	16	11
„ Furniture, books, and pictures	150	0	0
„ Subscriptions due	13	13	0
	£262	9	4

LIABILITIES.

By Rent of Rooms to 30th April	£ 12	10	0
„ Periodicals ordered	30	0	0
„ Assistant Secretary's salary from 1st January to 30th April...	13	6	8
„ H. W. Ingram (Collector)—Commission	4	19	9
„ Office Keeper	2	6	6
„ Balance of Assets over Liabilities	199	6	5
	£262	9	4

The Treasurer remarked that the expenditure had been larger last year than usual, in consequence of the Society having had to provide the necessary furniture for the rooms.

Mr. Wm. Neill moved the adoption of the Balance Sheet, and congratulated the members on the present very satisfactory position of the Society.

Mr. John Alger seconded the motion, and in so doing asked whether the books and picture belonging to the Society were insured.

The motion having been put from the Chair was carried, and the question of insurance was referred to the Council.

The Chairman announced that fifty donations had been received during the recess.

The Anniversary Address by the Revd. W. B. Clarke, F.R.S., Vice-President, was then read by the Revd. Wm. Scott, at the request of the Revd. W. B. Clarke.

Mr. Alfred Roberts asked what order it was proposed to take in the formation of the Sections suggested in the Address.

Professor Liversidge said, that at the next Council meeting a definite scheme would be drawn up—some suggestions might now be thrown out.

Mr. Alfred Roberts suggested that the Chairman of each Section should be *ex officio* a Member of the Council of the Society.

Copies of correspondence with respect to the exchange of scientific publications was laid before the members, viz. :—

In June last the Hon. Secretaries forwarded copies of the following circular to the Foreign Consuls resident in Sydney, accompanied by a request that they would exercise their interest to bring the same before the notice of the various Scientific Societies in their respective Countries:—

[CIRCULAR.]

THE ROYAL SOCIETY OF NEW SOUTH WALES.

The Society's Rooms, Sydney, 25 June, 1875.

The Royal Society of New South Wales desires to enter into correspondence with similar Scientific Societies and Institutions in other Countries, for the purpose of making a friendly interchange of information and publications. The annual Transactions published by the Society consist of original scientific articles, which usually relate to the Geography, Geology, Mineralogy, Natural History, Meteorology and General Resources of the Colony of New South Wales. Communications may be addressed to one of the Hon. Secretaries.

In addition to the above, there was appended a list of the Officers for the current year, and a copy of the Fundamental Rules of the Society.

To this circular favourable replies were returned, with cordial offers of co-operation.

Since the distribution of the circulars, the following communications have been received:—

Copy of letter received by the American Consul.

THE SMITHSONIAN INSTITUTION.

Washington, 20 November, 1875.

J. H. WILLIAMS, Esq., U.S. Commercial Agent, Sydney, N.S.W.

Dear Sir,—Your letter of September 11th, with the accompanying circulars from the Royal Society of New South Wales, was duly received; and after having endorsed the circulars in a note calling special attention to them, and an offer to be the medium of exchange between their recipients and the Royal Society, we duly distributed them to some of the principal Institutions of this Country. This Institution has charge of the National Museum, and is desirous of enriching it with specimens of Ethnology and Natural History from New South Wales. Anything, therefore, belonging to those branches of Science would be thankfully received, and the favour reciprocated by specimens from this Country.

I remain, etc.,

JOSEPH HENRY, Director, S. I.

Endorsement on Royal Society circulars.

SMITHSONIAN INSTITUTION.

"Washington, D.C., November, 1875.

"The Smithsonian Institution begs leave to call special attention to this circular, and to suggest that it will cheerfully take charge of any packages which you may desire to send to the Royal Society of New South Wales."

JOSEPH HENRY, Secretary, S.I.

SMITHSONIAN INSTITUTION.

Washington, 18 November, 1875.

Dear Sir,—Your letter addressed to Mr. Williams, Consul of the United States to New South Wales, was referred to this Institution, and it gives me pleasure to inform you that we will cheerfully co-operate with you in effecting an exchange between Societies in this Country and the Royal Society of New South Wales. The Smithsonian Institution, as you are probably aware, has established a great system of international exchange, through which most of the scientific publications of the United States, of Canada, and of South Central America, are distributed to different parts of the world. Our intercourse with Australia is through our Agent in London, Mr. W. Wesley, 28, Essex-street, Strand, to whom we would request you to send, addressed to us, anything you may desire distributed in the American Countries abovementioned. Besides publications, we are desirous, on our own part, to obtain objects of Natural History and Ethnology. Your circular will be distributed to the leading Scientific Societies of this Country, and especial attention will be called to it by an accompanying letter.

Respectfully and truly yours,

JOSEPH HENRY, Director, S.I.

PROFESSOR LIVERSIDGE,
Hon. Secretary, Royal Society, N.S.W., Sydney.

CONSULATE OF THE GERMAN EMPIRE.

Sydney, 10 May, 1876.

Sir,—With reference to your letter of 6th July, 1875, in which you informed me that the Royal Society of New South Wales was desirous of being placed in communication with similar Scientific Societies and Institutions in Germany, and in which you forwarded to me copies of the Fundamental Rules and other information relating to the Society, I have the honor to hand to you herewith translation of a letter bearing on this subject, which I received from the Foreign Office, Berlin, in reply to my report, and also beg to forward you 167 volumes, and two charts, as particularised in the list, enclosed herewith. The communication which has thus been established through the diplomatic channel between the Royal Society and the leading scientific Societies of Germany, will I trust be a permanent one, and of mutual advantage.

I have, &c.,

CARL L. SAHL, Imperial German Consul.

PROFESSOR LIVERSIDGE,
Hon. Secretary, Royal Society, Sydney.

FOREIGN OFFICE, BERLIN.

1 March, 1876.

Sir,—Referring to your report of 9th July, 1875, in which you intimate that the "Royal Society of New South Wales" wishes to enter into closer connection with Scientific Societies and kindred Institutions, for the purpose of interchanging publications of scientific tendencies, I have the honor to inform you that I have brought this under the notice of the Governments of Prussia, Bavaria, Saxony, Württemberg, Baden, and Sachsen Weimar, and now acquaint you with the result, so that you may take any further steps necessary.

With reference first to the SCIENTIFIC INSTITUTIONS of Prussia.

"The Royal Academy of Science" here (Königliche Akademie der Wissenschaften) has resolved to forward to the "Royal Society" their Monthly Report from the year 1860.

"The Royal Society of Science in Göttingen" (Königliche Gesellschaft der Wissenschaften in Göttingen), which is already exchanging publications with the Royal Society of Victoria, in Melbourne, is ready to enter into similar relations with the Royal Society of New South Wales, and from its publications it has sent in "The Communications of the Society of Sciences and the George Augustus University" (Nachrichten von der Gesellschaft der Wissenschaften und der Georg August Universität) for 1875, which contain principally transactions of their meetings, and communications on subjects of Natural Sciences and Mathematics, and of Historical and Philological interest.

"The Society of Natural History in Görlitz" (Naturforschende Gesellschaft in Görlitz) has also declared itself willing to exchange publications, and for this purpose has sent in three volumes of its present Report of Proceedings, as well as three volumes from a former period.

"The Society of Natural History of Prussian Rhinelands and Westphalia in Bonn (Naturhistorische Verein der Preussischen Rheinlande und Westphalens in Bonn) has some time ago expressed its readiness to Dr. LEIBIUS of the Royal Society, through its Secretary, Professor Andrä, to exchange publications, and has sent in a packet of publications under his address.

"The Society of Physics and Agriculture in Königsberg in Prussia" (Die Physikalisch-oeconomische Gesellschaft in Königsberg i/Pr.), as well as the "Geographical Society in Hamburg" (die geographische Gesellschaft in Hamburg), have also declared themselves ready to exchange publications, and the latter has sent in its two first Annual Reports of the year's proceedings.

"The Senckenberg Society of Natural History in Frankfurt a/M," (Senckenbergische naturforschende Gesellschaft in Frankfurt a/M) will enter into direct negotiations with the Royal Society, and fulfil their wishes.

From the ROYAL BAVARIAN GOVERNMENT.

I have been informed that the "Royal Academy of Science in Munich" (Königlische Akademie der Wissenschaften in München) is prepared to connect itself with the Royal Society, and to exchange with it its publications referring to Mathematical and Physical subjects (mathematisch physikalische Klasse). As to the other Scientific Societies of Bavaria which publish scientific books, the following nine are mentioned, and the Royal Society can, if they deem it advisable, put themselves in direct communication with them :—

1. "The Society of Natural History in Augsburg" (der Naturhistorische Verein in Augsburg). Publishes reports.
2. "The Society of Natural History in Bamberg" (die Naturforschende Gesellschaft in Bamberg). Publishes reports.
3. "The Pollichia in Deidesheim, Bavarian Palatinate" (die Pollichia in Deidesheim, Bayer. Pfalz). Reports.
4. "The Botanical Society in Landshut" (der Botanische Verein in Landshut). Reports.
5. "The Society of Natural History in Nürnberg (die Naturhistoriche Gesellschaft in Nürnberg). Reports.
6. "The Botanical Society in Regensburg" (die Botanische Gesellschaft in Regensburg). Botanical reports.
7. "The Zoological and Mineralogical Society in Regensburg" (der Zoologisch-mineralogische Verein in Regensburg). Paper for correspondents and reports.
8. "The Society of German Apothecaries in Speyer" (der Deutsche Apotheker Verein in Speyer). Yearly volume for Pharmacy.
9. "The Physical-Medical Society in Würzburg" (die Physikalisch-Medizinische Gesellschaft in Würzburg). Reports.

According to a communication from the ROYAL GOVERNMENT OF WURTTEMBERG,

"The Society of Natural Science in Württemberg" (der Verein für Vaterländische Naturkunde in Württemberg), at Stuttgart, is prepared with pleasure to connect itself with the Royal Society. This Society publishes every year three editions, with plates of subjects interesting to Natural History, and is prepared to exchange the publications from the year 1866, if the Royal Society will send its publications from the year of its foundation, 1866, and further annual publications. If the Royal Society should like to exchange objects of Natural History or dispose of them by sale, the Royal Cabinet of Natural History in Württemberg (Königlich Württembergisches Naturalien Kabinet) would be glad to enter into negotiations.

Also the Royal Bureau for Statistics and Topography at Stuttgart (Königlich Statistich-Topographisches Büreau zu Stuttgart) is prepared to connect itself with the Royal Society, and exchange publications. This Society is principally concerned with Statistics and Meteorology, and the two publications sent herewith give further information.

From the ROYAL GOVERNMENT OF SAXONY,

I have received a list of the following Societies which would be willing to be connected with the "Royal Society:"—

"The General Directorship of Royal Collections for Arts and Sciences in Dresden" (General-Direction der Königlichen Sammlungen für Kunst und Wissenchaft zu Dresden).

"The Statistical Bureau of the Ministry of the Interior at Dresden" (das Statistische Büreau des Ministeriums des Innern zu Dresden).

"The Imperial Leopold Caroline German Academy of Natural History at Dresden" (die Kaiserlich Leopoldinisch-Carolinisch Deutsche Akademie der Naturforscher zu Dresden).

"The Academy of Mines at Freyberg" (die Berg Akademie zu Freiberg).

Of the collection of publications bearing on Natural History, which the General Directorship of the Royal Collections intend to send regularly in future to the Royal Society, a number of publications have been sent, as per list herewith.

In the GRAND DUCHY of BADEN there are four Societies of Natural Science:—

1. "Society of Natural Science at Carlsruhe" (Naturwissenschaftlicher Verein zu Carlsruhe).
2. "Society of Natural Science" at Mannheim (Mannheimer Verein für Naturkunde).
3 "Society of Natural Science" at Freiburg (Naturforschende Gesellschaft zu Freiburg).
4. "Society of Natural History and Medicine" at Heidelburg (Naturhistorisch Medicinische Gesellschaft zu Heidelberg).

Only the first and third of the above Societies have so far decided to connect themselves with the Royal Society, and the Reports for the years 1870–73 of the Society of Natural Science are sent herewith.

Finally, I wish to mention that the "Society of Medicine and Natural Science," at the University of Jena (die Medizinisch Naturwissenschaftliche Gesellschaft der Universität Jena) has resolved to send to the Royal Society regularly a copy of their Jena Pamphlet for Natural Science, (Jenaische Zeitschrift fur Naturwissenschaft), and thus enter into the desired connection with that Society.

THE CHANCELLOR,
By order,
B. BULOW.

To CARL L. SAHL, ESQ.,
Imperial German Consul, Sydney.

LIST OF BOOKS FOR THE ROYAL SOCIETY.

"Königliche Akademie der Wissenschaften, Berlin." Monthly reports from 1860. 146 volumes.

"Nachrichten von der Gesellschaft der Wissenschaften, and der G. A. Universität, 1875." 1 volume.

"Naturforschende Gesellschaft in Görlitz." 6 volumes, 2 charts.

"Geographische Gesellschaft, Hamburg." 2 reports.

"Königlich statistisch-topographisches, Bureau." 2 reports.

"Naturforschende Gesellschaft, Freiburg." 4 Reports 1870–73.

"General Directorship of Royal Collection for Arts and Science, Dresden": (1) Die Urnenfelder von Strehlen. (2) Geologie von Sumatra. (3) Der Arabische Himmelsglobus. (4) Mittheilungen aus dem Königl. Geol. Museum, Dresden. (5) Mittheilungenüber die Sammlungen des Königl. Mathem-Physikal. Salons. (6) Katalog der Sammlungen der Königl. Mathem. Physikalischen. Salons.

167 volumes and 2 charts.

German Consulate, Sydney, May 10, 1876. CARL L. SAHL, Consul.

MUSEUM OF NATURAL HISTORY.

Paris 27, January 27, 1876.

A letter from Professor E. CHEVREUL, Director, acknowledging the receipt of eight volumes of the Transactions of the Royal Society of N.S.W., from 1867 to 1874, and promising to transmit to the Society a collection of ethnological photographs which is in preparation.

The Rev. WM. SCOTT referred to the suggestions in the Address of the Chairman, as to seeking a grant from the Government: they were entering on enlarged expenditure, and would need help.

Mr. H. C. RUSSELL thought they might obtain Government aid if they represented the case properly. There was no Library in the Colony that might be called a Scientific Library; that was one of their requirements. A Committee should be appointed to form a deputation to the Government on the subject.

Mr. TREBECK recommended the appointment of such deputation, and suggested that an annual endowment would be more serviceable than a large sum.

Mr. BENSUSAN thought that they should now ask for a fixed sum to stock their Library.

After some further discussion, it was moved by Mr. H. C. RUSSELL, seconded by Mr. WM. NEILL, and carried:—That the following members of the Society, viz., The Hon. Francis Lord, M.L.C., the Hon. John Hay, M.L.C., Rev. Dr. Lang, Rev. W. B. Clarke, Professor Liversidge, Dr. Leibius, Rev. Wm. Scott, John Squire Farnell, Esq., M.P., Charles Moore, Esq., and the mover, be appointed a Committee to seek assistance from the Government, and that the manner in which this assistance will be asked shall be left to the Committee.

It was then decided that the Committee should meet at the Rooms on Monday next, at 4 p.m.

WEDNESDAY, 7TH JUNE, 1876.

Ordinary monthly meeting of the Royal Society of New South Wales, held in the Society's Rooms, Elizabeth-street.

The Rev. W. B. Clarke, V.P., in the Chair.

The minutes of the last meeting were read and confirmed.

The following gentlemen were duly elected ordinary members of the Society, viz. :—

Rev. W. F. Roberts, B.A.	A. S. Webster.
George Evans.	Houlton H. Voss.
W. F. M'Carthy.	Henry James Brown.
The Hon. Saul Samuel, C.M.G., M.L.C.	John Eales.
	John Y. Dalgarno.
H. E. Southey.	W. H. M'Guire.
Rev. E. M. Saliniere.	Walter Hugh Tibbits.
H. Arding Thomas.	Rev. P. F. Mackenzie.
W. A. Murray.	J. M. Marsh, P.M.

Twelve new candidates were proposed and seconded.

The Chairman reported to the members that the Committee, appointed at the last meeting for the purpose of seeking assistance from the Government, had waited as a deputation upon the Honorable the Minister for Justice and Public Instruction on the 26th inst., and had submitted a request to be communicated to the Government for the sum of £2,500, for the erection of a suitable building, and £300 annually for the ordinary purposes of the Society.

The deputation was courteously received, and the Minister promised to bring the matter before his colleagues.

Memorandum subsequently forwarded to the Honorable the Minister for Justice and Public Instruction :—

Reasons for the Application for Assistance.

1. *Popular scientific lectures*—To enable the Society to institute courses of popular scientific lectures.

2. *Working Sections*—To permit the establishment of working Sections of the Society for the promotion of special branches of science.

3. *Scientific library*—To enable the Society to form a library of standard scientific works.

4. *To collect and distribute publications*—To found a central institution in New South Wales for the exchange of scientific publications between the Institutions of this Colony and those of other countries. Recent experience has shown that the Transactions of this Society will be received as an equivalent for the publications of most of the leading Societies of Europe and America.

5. *Scientific investigations*—In England similar scientific Societies afford valuable information to the Government on many subjects. The Royal Society of Sydney has done something in the past, and is anxious to do more in the future.

6. *Insufficient funds*—The money at its disposal will not permit the Society to maintain even its present relations with the public and other Societies, and it is totally inadequate to carry out the contemplated extended scheme of usefulness.

7. £5,000 *subscribed—Assistance sought*—Since its commencement, the Society has subscribed upwards of £5,000 for the promotion of science and higher education in the Colony, and the undersigned now respectfully ask in the name of the Society for assistance from the Government, in order that they may make their past labours and present capabilities of more use to the public. The principal English scientific Societies are provided with suitable accommodation, Burlington House having been recently rebuilt at great cost expressly for this purpose; and the Royal Society of London has large sums of money annually placed at its disposal by the Government.

Other Societies receive aid—They feel that they are justified in making this request, because other Societies established here to educate and instruct the public receive grants of money and assistance.

Societies in other Colonies—The corresponding Societies in Victoria, New Zealand, and Tasmania, are liberally supported and provided with suitable buildings by their respective Governments.

Under these circumstances the undersigned members were appointed a deputation to wait upon the Minister for Justice and Public Instruction to request him to take the case of the Royal Society of New South Wales into his favourable consideration, and to obtain for it an annual grant equal to the subscriptions, and to provide it with suitable buildings, or a money grant to help in securing such building or other accommodation for lecture-rooms, library, and offices:—

Signed:—	W. B. Clarke.	A. Lang.
	H. C. Russell.	C. Moore.
	Francis Lord.	A. Leibius.
	J. S. Farnell.	A. Liversidge.

The new Bye-laws brought forward by the Council were read *seriatim* by the CHAIRMAN, and were adopted.

Several donations were laid upon the table.

A letter was read from Mr. Ellery, Government Astronomer of Victoria, acknowledging the honorary membership conferred upon him.

It was then decided that the preliminary meetings of the various Sections should take place in the Society's Rooms on the following dates, at 8 p.m., viz.:—

Section	A—Astronomy, &c.	June 19
„	B—Chemistry, &c.	„ 20
„	C—Geology, &c., Temp. Amal. with B	„ 21
„	D—Biology (To be arranged.)	„ 22
„	E—Microscopy	„ 23
„	F—Geography	„ 26
„	G—Literature and Fine Arts	„ 27
„	H—Medical	„ 28
„	I—Sanitary and Social	„ 29

Mr. H. C. RUSSELL then read a paper entitled "Notes on some remarkable errors shown by Thermometers."

Mr. H. C. RUSSELL also exhibited an improved form of Heliostat for signalling.

After a few remarks from the Rev. WM. SCOTT the meeting adjourned until the 5th July.

WEDNESDAY, 5TH JULY, 1876.

Ordinary monthly meeting of the Royal Society of New South Wales, held in the Society's Rooms, Elizabeth-street.

The Rev. W. B. Clarke, V.P., in the Chair.

The minutes of the last meeting were read and confirmed.

The following gentlemen were duly elected ordinary members of the Society, viz.:—

William George Tayler, F.R.C.S., London, 219, Pitt-street.
W. H. Eldred, 119, Castlereagh-street.
Archibald Atcheson, North Shore.
William Hedley Drake, Commercial Bank, Inverell.
The Hon. Alexander Campbell, M.L.C., Woollahra.
W. A. Brodribb, Riverina.
W. O. Gilchrist, Union Club.
James Osborne, Wollongong.
William Forde, 4 Carlton Terrace, Wynyard Square.
Henry Heron, William-street South.
Thomas S. Parrott, Ashfield.
John Leo Watkins, B.A., Randwick.

The certificates of thirty candidates were read.

The Honorary Treasurer drew the attention of members to the 15th Bye-law, providing for the posting up in the Rooms of the Society of the names of members who are in arrears with their annual subscriptions, and stated that he had not prepared the list for this meeting because the new Rules were only passed in June, but that in future this Bye-law would be strictly enforced.

Professor Liversidge then gave an account of the meetings of the several Sections according to appointments made at the last meeting of the Society. Section C, on Geology and Palæontology, had been amalgamated with Section B, on Chemistry and Mineralogy. It had also been decided by the Council that Section H should include Medical Science only; and that Section I should include Sanitary and Social Science and Statistics.

Professor Liversidge further reported that the following gentlemen had been elected officers of the undermentioned Sections, viz.:—

Section A—Astronomical and Physical Science.—Chairman: H. C. Russell, B.A., F.R.A.S. Committee: G. D. Hirst, H. A. Lenehan, Rev. W. Scott, M.A., and Dr. Wright. Secretary: J. M'Donald, F.R.A.S.

Section B—Chemistry and Mineralogy, with which is incorporated Section C—Geology &c.—Chairman: Professor Liversidge. Committee: S. L. Bensusan, J. W. M'Cutcheon, J. S. Sleep, W. F. Tulloh. Secretary, W. A. Dixon, F.C.S.

Section E—Microscopy.—Chairman: A. Roberts, M.R.C.S. Committee: Dr. Milford, Dr. Belgrave, W. MacDonnell, Hugh Paterson. Secretary: G. D. Hirst.

Section F—Geography, &c.—Chairman: E. Du Faur, F.R.G.S. Committee: Hon. L. De Salis, M.L.C., J. Manning, C. L. Sahl, A. S. Webster. Secretary: W. Forde.

Section G—Literature and Fine Arts.—Chairman: E. L. Montefiore. Committee: Hon. L. De Salis, M.L.C., E. Du Faur, F.R.G.S., W. G. Murray, C. A. Morell. Secretary: H. A. Lenehan.

Section H—Medical Science.—Chairman: A. Roberts, M.R.C.S. Committee: Dr. Milford, Dr. Morgan, Dr. Cox, H. G. Wright, M.R.C.S. Secretary: Dr. Sydney Jones.

Section I—Sanitary and Social Science had not yet met to elect officers.

Twelve donations were laid upon the table by the Chairman.

The Rev. Dr. Lang then read his paper—"On the Origin and Migration of the Polynesian Nation, and their original discovery, possession, and settlement of America; with a critical examination of Mr. Bancroft's work upon the Native Races of the Pacific States of North America."

Mr. H. C. Russell, the Government Astronomer, exhibited a clock with an appliance for correcting the time every hour, by means of an electro-magnet connected with a regulator. This method had been invented by Mr. Russell for the purpose of regulating the clock at the Railway Terminus, Redfern, by the standard clock at the Observatory.

THURSDAY, 20 JULY, 1876.

Extra Meeting of the Royal Society of New South Wales, held in the Society's Rooms, Elizabeth-street.

The Revd. W. B. Clarke, V.P., in the Chair.

The minutes of the last meeting were read and confirmed.

The following gentlemen were duly elected ordinary Members of the Society, viz.:—

Arthur Todd Holroyd, M.D., M.B. (Cantab), F.L.S., F.R.G.S., Sherwood Scrubs, Parramatta.
The Hon. Wm. Graham, M.L.C., Union Club, Sydney.
Alfred Cadell, Vegetable Creek, New England.
J. T. Toohey, Melrose Cottage, Cleveland-street.

James Burleigh Sharpe, J.P., Yass.
Rev. Frank Firth, Newcastle.
George Foster Wise, Darlinghurst.
Rudolf Schütte, M.D., Univ. Göttingen, Lic. Soc. Apoth., Lond., 10, College-street.
Thomas Henry Gilman, M.D., Queen's Univ. Irel., Mast. Surg. Queen's Univ. Ire., Lic. Mid. K. & Q. Coll. Phys. Irel., College-street.
Wm. Gillett Sedgwick, M.R.C.S. England, Newtown.
Thos. Stackhouse, Commander R.N., Australian Club.
Henry Norman Maclaurin, M.D., Univ. Edin. Lic. R. Coll. Sur. Edin., Lic. Mid. R. Coll. Sur. Edin., 187, Macquarie-street.
Fredk. Norton Manning, M.D. Univ. St. And., M.S.C.S. Eng., Lic. Soc. Apoth., Lond., Gladesville.
Louis Thos. Laure, M.D., Surg. Univ. Paris, 131, Castlereagh-street.
Allan Bradley Morgan, M.R.C.S., Eng., Lic. Mid. Lic. R. Coll. Phys., Edin., Burwood.
Fredk. Harrison Quaife, M.D., Univ. Glas., Mast. Surg. Univ. Glas., Piper-street, Woollahra.
Wm. Conder, Survey Office, Sydney.
W. C. Windeyer, M.A., M.L.A., King-street.
F. H. Trouton, A.S.N. Company's Offices, Sydney.
Chas. Kinnard Mackellar, M.B., C.M. (Glas.), Lyons' Terrace.
George Marshall, M.D., Univ. Glas., Lic. R. Coll. S.; Edin. Lyons' Terrace.
Andrew John Brady, Lic. K. & Q. Coll. Phys., Irel., Lic. Mid. K. & Q. Coll. Phys., Irel., Lic. R. Coll. Sur., Irel., Sydney Infirmary.
Charles M'Kay, M.D., Univ. St. And., Lic. R. Coll. Surg., Edin., Church Hill.
Thos. Wm. Keele, Harbours and Rivers Department, Phillip-street.
Michael Joseph Clune, Lic. K. & Q. Coll. Phys. Irel., Lic. R. Coll. Surg. Irel., 4 Hyde Park Terrace.
Benjamin Fyffe, M.R.C.S., England, Castlereagh-street.
John Wilson Alston, M.B., Edin., Mast. Surg. Edin., 455, Pitt-street.
Wm. James Barkas, Lic. R. Col. Phys. Lon. M.R.C.S., Eng., Bombala.
Henry William Jackson, L.R.C. Surg., Edin., Lic. R. Phys., Edin., 130, Phillip-street.
John Cash Neild, M.D., Sydney, M.R.C.S., Eng., Lic. Soc. Apoth., Lon.

The certificates of nineteen new candidates were proposed and seconded.

In reference to the books and periodicals of the Society, the Chairman announced to the meeting that the Council had passed the following minute, viz.:—"That the books and periodicals of the Royal Society of New South Wales can not be open to the members generally until the Society has rooms of its own in which proper convenience for reading can be provided."

Professor LIVERSIDGE reported that Section I—Sanitary and Social Science—had been established since the last meeting, and that the following gentlemen had been elected officers of the Section, viz.:—Chairman, A. Roberts, M.R.C.S.; Committee, J. G. Bedford, M.R.C.S., Dr. Morgan, W. Tarleton, H. H. Voss; Secretary, Harrie Wood; and that the days for the sectional meetings would be as follows:—

	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Section A—Astronomy, &c. Wednesday ...	26	30	27	25	29	27
" B—Chemistry, &c. Wednesday......	12	9	13	11	8	13
" C—Geology, &c., Temp. Amal. with B.						
" D—Biology (To be arranged).						
" E—Microscopy. Wednesday.........	19	16	20	18	15	20
" F—Geography. Monday..............	17	21	18	16	20	18
" G—Literature & Fine Arts. Monday	24	28	25	23	27	26
" H—Medical. Thursday		10	14	12	9	14
" I—Sanitary and Social. Tuesday...	11	8	12	10	14	12

Twenty donations were laid upon the table.

The Revd. DR. LANG then read the concluding portion of his paper "On the Origin and Migration of the Polynesian Nation, and the Original Discovery, Possession and Settlement of America, with a critical examination of Mr. Bancroft's work upon the Native Races of the Pacific States of North America."

The Rev. W. B. CLARKE then read a paper "On Deep Submarine Depressions off Moreton Bay."

Mr. H. C. RUSSELL exhibited and explained one of Crooke's Radiometers which he had just received from England.

WEDNESDAY, 2 AUGUST, 1876.

Ordinary monthly meeting of the Royal Society of New South Wales, held in the Society's Room's Elizabeth-street.

The Rev. W. B. CLARKE, V.P., in the Chair.

The minutes of the last meeting were read and confirmed.

The following gentlemen were duly elected ordinary Members of the Society:—

W. E. Langley, *Herald* Office, Sydney.
Benjamin Backhouse, Elizabeth Bay.
J. Waterhouse, M.A. (Sydney), Newington College, Parramatta.
Thos. R. Icely, Carcoar.

Richard Lewis Jenkins, M.R.C.S., Nepean Towers, Douglass Park.
Douglas Dixon, Australian Club.
Richard Frean, Sydney Infirmary.
Myles Egan, Surgeon, 2 Hyde Park-terrace, Liverpool-st.
Wm. Edmund Strong, M.D., Liverpool.
Andrew Robertson Cameron, Physician, Richmond.
W. Lyons, Woollongong.
Chas. Henry Myles, Wymela, Burwood.
C. Russell Watson, Surgeon, Newtown Road, Newtown.
Owen Spencer Evans, Surgeon, Darling-street, Balmain.
Richard P. Jones, M.D., Ashfield.
James Douglas, Surgeon, Glebe Road, Glebe.
Gordon Davidson, M.D., Goulburn.
Isaac Waugh, M.B., T.C.D., Parramatta.
Allan Campbell, Surgeon, Yass.

The certificates of nineteen new candidates were read.

A letter was read from the Literature and Fine Art Section, which that Section intended to address to the Colonial Secretary, urging upon the Government the desirability of introducing the Woodbury process of Photography into this Colony, for the purpose of keeping an authentic and permanent record of Colonial maps and scenes. It was stated that the process could be obtained for £300.

Mr. H. C. Russell said it was thought that the letter would have more weight if it were signed by the members of the Society generally, and it was accordingly brought to the meeting for that purpose.

Twenty-eight donations were laid upon the table.

Mr. G. D. Hirst then read his paper, entitled "Notes on Jupiter during his opposition, 1876," which he illustrated with numerous drawings.

The Rev. W. B. Clarke laid on the table, for the inspection of the members, one of the curious chipped stones supposed to have been shaped by the primitive inhabitants of Europe, and which had been sent to him from Belgium.

WEDNESDAY, 6th SEPTEMBER, 1876.

Ordinary monthly meeting of the Royal Society of New South Wales, held in the Society's Rooms, Elizabeth-street.

The Rev. W. B. Clarke, V.P., in the Chair.

The minutes of the last meeting were read and confirmed.

The following gentlemen were duly elected ordinary Members of the Society:—

E. G. Tennant, M R.C.S.E., Orange.
Thos. Cecil Morgan, Lic. R.C.S.E., L.M.R.C.S., Ireland, Australian Club.
F. B. Gipps, Strathspey House, Macquarie-street.
George Goodie, M.B., Univ. Dub., Camden.
W. F. Bassett, M.R.C.S.E., Bathurst.
Chas. Parbury, Union Club.
John Shields, M.R.C.S., Ed., Bega.
W. H. Quodling, Burwood.
Rev. Henry Shaw Millard, Newcastle Grammar School.
Henry Sharp, Green Hills, Adelong.
Rev. George Martin, Newtown.
E. H. C. Bristowe.
A. H. M'Culloch, jun., 165, Pitt-street.
Wm. Smith Thomas, M.R.C.S.E., Wollongong.
James Aberdeen Jones, Lic. R.C. Phys., Edin., Balmain.
John Fredk. Codrington, M.R.C.S.E., Lic. R.C. Phys., L.; Lic. R.C. Phys., Edin.
Saml. Fredk. Tollett Milford, M.R.C.S.E., M.B. Univ. Heidelberg, College-street.
J. P. Josephson, 253 Macquarie-street North.
Samuel Bennett, Little Coogee.

The certificates of four new candidates were read.

Fourteen donations were laid upon the table.

The first of a series of papers by Mr. Barkas, M.R.C.S., "On the genus Ctenodus of the Coal Measures of Great Britain," was read by Mr. Edward Ramsay, in the absence of the author.

The paper was illustrated by drawings.

Professor LIVERSIDGE then read his paper "On the formation of Moss Gold," which he illustrated by numerous specimens.

Teeth of the Ceratodus from Würtemberg were exhibited by the Rev. W. B. Clarke.

WEDNESDAY 4TH OCTOBER, 1876.

Ordinary monthly meeting of the Royal Society of New South Wales, held in the Society's Rooms, Elizabeth-street.

H. C. RUSSELL, V.P., in the Chair.

The minutes of the last meeting were read and confirmed.

The following gentlemen were duly elected ordinary members of the Society, viz.:—

Wm. Hoxton Hayley, M.R.C.S., Ed., Goulburn.
Clarendon Stuart, Upper William-street, South.
Chas. Marshall Fisher, 173, Pitt-street.
Thos. Pickburn, M.B., Aberdeen, College-street.

Seventeen new candidates were proposed and seconded, including seven members of the Sydney Botanical Society.

Communications from the Sections.

Section A. ASTRONOMY. Mr. H. C. RUSSELL read extracts from the *Gazette* of Thursday, June 30th, 1836, from the *Colonist* of Thursday, 30th June, 1836, and from the *Australian* of Tuesday, July 5th, 1836, in reference to a heavy fall of snow in Sydney, on Tuesday morning, the 28th June, 1836.

Section I. SANITARY AND SOCIAL SCIENCE. Mr. ALFRED ROBERTS submitted a Report from the above Section, which, as the result of its deliberations, had adopted the following resolution, viz.:—

> That the Royal Society of New South Wales be invited by this Section to wait upon the Government by deputation and urge it to introduce during the next Session an efficient General Public Health Act, and to appoint a Central Board with ample powers to enforce its provisions.

In pursuance of the above resolution, Mr. ALFRED ROBERTS moved.

> That a deputation of this Society, consisting of the following gentlemen, viz.:—

The Vice-Presidents and the Secretaries.

Alger John, Esq.,
Allen The Hon. George Wigram, Esq., M.L.A.
Belgrave Dr.
Burton Edmund, Esq.
Cox Dr.
Dangar F. H., Esq.
Dibbs G. R., Esq., M.L.A.
DeSalis The Hon. Leopold Fane, M.L.C.
Fairfax The Hon. John, M.L.C.
Farnell J. S., Esq., M.L.A.
Goodlet John H., Esq.
Hay The Hon. John, M.L.C.
Holt, The Hon. Thos., M.L.C.
Jones Dr. Sydney
Knox Edward, Esq.
Lord The Hon. Francis, M.L.C.
Lloyd G. A., Esq., M.L.A.
Manning James, Esq.
Mansfield G. A., Esq.
Milford Dr.
Morgan Dr. C. W.
Murray W. G., Esq.
M'Lauren Dr.
Neill Wm., Esq.
Neild Dr.
Pell Professor, B.A.
Smith Professor, M.L.C.
Scott Rev. W., M.A.
Spencer W., Esq.
Roberts Alfred, Esq.
Trebeck P. N., Esq.
Ward Dr.
Weigall A. B., Esq., B.A.
White Hon. Jas., M.L.C.
Wood Harrie, Esq.
Wright H. G. A., Esq.

> And such other members as shall be willing to attend, be appointed to wait upon the Government to urge it to introduce during the next Session an efficient General Public Health Act, and to appoint a Central Board with ample power to enforce its provisions.

The above resolution was seconded by Mr. WM. NEILL, and carried.

Ninety-seven donations were laid upon the table, and thanks were ordered for them.

A Paper "On the Microscopic Structure of the Teeth of Ctenodus" by Mr. BARKAS, M.R.C.S., was read by Professor LIVERSIDGE.

Mr. S. L. BENSUSAN then read his paper "On recent Copper-extracting Processes."

A paper by the Rev. J. E. TENISON WOODS, F.G.S., F.L.S., "On some Tertiary Australian Polyzoa, illustrated by Drawings," was read by Professor LIVERSIDGE.

The Chairman then exhibited a Thermo-Electric Battery, and illustrated its utility by a variety of experiments.

The reading of Mr. Russell's paper "On Meteorological Periodicity" was postponed until the 13th of October.

The meeting then adjourned until the 13th instant.

FRIDAY, 13TH OCTOBER, 1876.

Extra meeting of the Royal Society of New South Wales, held in the Society's Rooms, Elizabeth-street.

The Rev. W. B. CLARKE, V.P., in the Chair.

The minutes of the last meeting were read and confirmed.

The following gentlemen were duly elected ordinary members of the Society, viz. :—

F. Ratte, Noumea, New Caledonia.
Henry Toller Wilkinson, Department of Mines.
Thomas Brown, Eskbank, Bowenfels.
Rev. Dr. J. A. Quirk, O.S.B., LL.D., Sydney, Lyndhurst College.
J. H. Heaton, Pitt-street.
Fredk. C. Jarrett, 292, George-street.
Dr. Rowling, Mudgee.
Wm. Henry Suttor, J.P., Cangoura, Bathurst.
Clement A. Benbow, 24, College-street.
James Henry Brown, Moncur-street, Woollahra.
R. S. Smith, Surveyor General's Office.
J. D. Reece, Surveyor General's Office.
Arthur J. Stopps, Surveyor General's Office.
R. D. Fitzgerald, F.L.S., Surveyor General's Office.
Aroid Nilson, Department of Mines.
W. D. Armstrong, Surveyor General's Office.
F. B. W. Woolrych, 38, Cumberland-street.

The certificates of four new candidates were read.

Two donations were laid upon the table.

Mr. H. C. Russell then read his paper on "Meteorological Periodicity."

A discussion ensued, in which Professor Smith, the Hon. Leopold Fane de Salis, Mr. Du Faur, Dr. Belgrave, and the Chairman took part.

WEDNESDAY, 1st NOVEMBER, 1876.

Ordinary monthly meeting of the Royal Society of New South Wales, held in the Society's Rooms, Elizabeth-street.

The Rev. W. B. Clarke, V.P., in the Chair.

The minutes of the last meeting were read and confirmed.

The following gentlemen were duly elected ordinary members of the Society, viz.:—

W. R. George, 172, Castlereagh-street.
Ernest Docker, Macleay-street.
Bernard Austin Freehill, 130, Elizabeth-street.
George Frederick Dansey, M.R.C.S., London, York and Margaret Streets, Wynyard Square.

Five new candidates were proposed and seconded.

Public Health Act.

Mr. H. C. Russell stated that at the last meeting a deputation was appointed by the Society to wait on the Colonial Secretary, for the purpose of urging him to introduce some measure for the improvement of the sanitary condition of the city. The deputation saw the Honorable the Colonial Secretary on the 31st October, and he informed them that if the Society would undertake to prepare a Bill he would assist and if possible get it passed. Mr. Russell further stated, that though this was not a subject that he had thought much of, he considered the Society ought to do all in their power to get a Bill passed that would remove all offensive things from their streets. It might be thought that in framing a Bill the Society would be taking upon them in some sort a political duty. That was a matter that ought to be carefully looked at. But still he felt so much the desirability of pressing the matter forward that he would move the following resolution:—"That the request of the Honorable Colonial Secretary, conveyed through the deputation which waited on him on the 31st ultimo, to urge the necessity for passing a Public Health Bill be complied with, and that a Committee, consisting of the Chairman and Secretaries of the Medical and Sanitary Sections, W. G. Murray, Esq., and the Honorary Secretaries of the Society, be appointed to prepare, with the Parliamentary Draftsman, a Public Health Bill; and that such Committee be empowered to sit during the prorogation of the Society's session, and to submit such Bill to the Colonial Secretary when completed."

Mr. Roberts said that the Colonial Secretary had offered the Society the services of a Parliamentary Draftsman and of the Government Printer to aid them. That appeared to him to show the Colonial Secretary's earnestness in the work, and he for one felt that he could see the way clear before the Society to do a great good to the community. He saw the difficulty mentioned by Mr. Russell; but this appeared to him to be an exceptional case, and one that was hardly political in its character. He thought they might perhaps get over the difficulty by appending to Mr. Russell's resolution words in effect disavowing any political object on the part of the Society, and stating that it was only in view of the sad condition of the Colony, and in the cause of humanity, that it determined to take the work up. The work would no doubt be very arduous. It required special knowledge, and there was no other body that he was aware of equally capable of dealing with it, except the Sewage and Health Board. He should personally be glad to be relieved from the work, but he would not shirk it if it were felt to be desirable.

The Honorable Francis Lord seconded the resolution.

Dr. Belgrave and Mr. Murray spoke in favour of the resolution.

Mr. Charles Moore and the Rev. Wm. Scott opposed the resolution.

Professor Liversidge did not think the Society should interfere in any way whatever with legislation. They might give some general suggestions to the Government, and what was done had better be done by the Sections of the Society—by the Committees of the Sanitary and Medical Sections.

The Chairman also thought that the matter had better be left with the Sections.

The Rev. Mr. Scott moved, as an amendment, the omission of all the words after the word "be," with the view to insert the following words—"requested to draw up a series of suggestions to be submitted to the Government with a view to the preparation of such Bill."

Dr. Neild seconded the amendment. He thought that whatever was done by the Sections of the Society would be regarded as done by the Society itself.

Mr. Roberts said, that if they confined their action to merely giving a few suggestions the matter would fall through.

The amendment was then put to the meeting from the Chair, and negatived, and the resolution was carried.

Mr. H. C. Russell then moved, "That the Secretary be directed to inform the Colonial Secretary of the foregoing resolution, and to request that a Parliamentary Draftsman be appointed to act with the Committee."

The motion was seconded by Dr. Belgrave, and carried.

Three donations were laid on the table, and the thanks of the Society ordered for them.

The following papers were received from Mr. Barkas, M.R.C.S:

"On the Microscopical structure of the Teeth of Ctenodus," Part 3; and

"On the Dentary, Articular, and Pterygo-palatine Bones of Ctenodus," Part 4.

The Rev. W. B. CLARKE then read his paper "On the effects of Forest Vegetation on Climate."

A discussion ensued in which Mr. Charles Moore and the Chairman took part, and the further discussion of the paper was adjourned until the next meeting.

EXHIBITS.

Mr. W. M'Donald exhibited and explained the action of Tate's new form of air-pump.

Mr. Colyer exhibited a specimen of coral, which was of special interest, inasmuch as it had been found by the cable-ship "Edinburgh," adhering to the cable laid between Port Darwin and Banjowangie, about 270 miles from Port Darwin, and taken from a depth of 150 feet. The coral was three or four inches in thickness, and bore the marks of the cable, which it had overgrown to the extent named.

WEDNESDAY, 6TH DECEMBER, 1876.

Ordinary monthly meeting of the Royal Society of New South Wales, held in the Society's rooms, Elizabeth-street.

The Rev. W. B. CLARKE in the Chair.

The minutes of the last meeting were read and confirmed.

The following gentlemen were duly elected ordinary Members of the Society, viz.:—

George B. Montefiore, 5, Gresham-street.
John Martin, Ryde.
Wm. Christie, L.S., Hawthorn Lodge, Glen Innes.
A. W. Scott, M.A. (Cantab), Ferndale, New South Head Road.
Alfred Chandler, Post Office-street.

HONORARY MEMBERS:—

In accordance with a recommendation from the Council, Professor L. G. DE KONINCK, M.D., of the University of Liege, and SIR JAMES COCKLE, M.A., F.R.S., Chief Justice of Queensland, were duly elected Honorary Members of the Society.

The certificates of two new candidates were read.

Donations were laid upon the table. The Chairman announced that the Council intended to make arrangements next year to open the office as a Reading Room on three nights a week, in addition to Wednesday afternoon as at present.

SOCIAL AND SANITARY SECTION.

PROFESSOR LIVERSIDGE read a letter from the Social and Sanitary Section of the Society, requesting the co-operation of the Society with the Agricultural Society for the exhibition of articles tending to promote sanitary science, and to improve sanitary appliances.

Moved by Mr. H. C. RUSSELL, seconded by the Rev. WM. SCOTT, and carried,—That the above letter be referred to the Council of the Society.

PUBLIC HEALTH BILL.

A letter was read from the Colonial Secretary's Department, acknowledging the receipt of a letter from the Society requesting the appointment of a Parliamentary Draftsman to act with the Committee deputed by the Society to prepare a Public Health Bill, and stating that although what was set forth in the resolutions of the Society concerning a request of the Colonial Secretary was incorrect, the Premier (Mr. ROBERTSON) was not unwilling to arrange that the assistance of a Draftsman be given to the Society in the work it had in view, and he would accordingly make arrangements to that end.

Notice of Motion :—The Rev. WM. SCOTT gave notice that at the May meeting he should move,—"That in future no motion be made, of which notice has not been given at a previous meeting, excepting motions of adjournment or others of a formal character."

MR. CHARLES MOORE then read a paper by Mr. W. CHRISTIE, "On the Forest Vegetation of Central and Northern New England, in connection with Geological Influences."

The discussion on the Rev. W. B. CLARKE's paper entitled "Effects of Forest Vegetation on Climate," was resumed. The following gentlemen took part in the debate, viz. :—Mr. Charles Moore, Mr. Brodribb, Dr. Neild, Mr. Dixon, Rev. Wm. Scott, Mr. Russell, and the Chairman.

The CHAIRMAN brought before the notice of the meeting an American publication "On Forest Culture," intended to encourage the cultivation of the Eucalyptus in America.

The following papers were then read by Professor LIVERSIDGE, viz. :—

1. On Fossiliferous Silicious Deposit from the Richmond River, and
2. "On a remarkable specimen of contorted Slate."

The papers were illustrated by geological specimens.

Mr. Makin exhibited specimens of shale and coal from the Berrima District, and stated that he would read at some future meeting a paper "On the mineral productions of Berrima."

The meeting then adjourned until May.

ADDITIONS

TO THE

LIBRARY OF THE ROYAL SOCIETY OF NEW SOUTH WALES.

DONATIONS—1876.

The names of the Donors are in *Italics*.

REPORTS, OBSERVATIONS, &c.

ADELAIDE:—South Australian Institute, Annual Report, 1875–6.—*The Institute.*

ALBANY, N.Y.:—Manual for the use of the Legislature of the State of New York, 1871.

Civil List and Forms of the Colony and State of New York. Fifty-fifth, Fifty-sixth, and Fifty-seventh Annual Report of the Trustees of the New York State Library.

Twentieth, Twenty-first, Twenty-second, Twenty-third, Twenty-fourth, and Twenty-fifth Annual Report of the Regents of the University on the condition of the State Cabinet of Natural History; with Plates.

Report of the Regents of the University on the Boundaries of the State of New York.

Catalogue of the New York State Library, 1872.

Meteorology 1826–1850, and from 1850–1863. Second Series.—*The State Library, Albany, N.Y.*

BERLIN:—Königliche Akademie der Wissenschaften, Berlin. Monthly Reports, from 1860. 15 vols.—*The Academy.*

Nachrichten von der Gesellschaft der Wissenschaften, und der G. A. Universität, Göttingen, 1875.

Königliche Statistisch-topographische Bureau. Two Reports.—*The Bureau.*

BONN:—Verhandlungen Naturhistorischen Vereines der Preussischen Rheinlande und Westphalens.—*The Society.*

CALCUTTA:—Records of the Geological Survey of India. Vol. VIII, Part 1, 2, 3, and 4, 1875.

Records of the Geological Survey of India. Vol. IX. Part 1. 1876.

Memoirs of the Geological Survey of India. Vol. X.

Memoirs of the Geological Survey of India. Vol. XI.

Palæontologia Indica; being Figures and Descriptions of the organic Remains procured during the progress of the Geological Survey of India.

Palæontologia Indica. Vol. I. 4.

Jurassic Fauna of Kutch. Vol. 1, 2, Ser. IX. The Cephalopoda (Ammonitidæ). By Wm. Waagen, Ph. D. With Plates.

Do., do., do., Ser. IX. The Belemnitidæ and Nautilidæ.
—*Thos. Oldham, LL.D., F.R.S., Superintendent of the Geological Survey of India.*

CAMBRIDGE, U.S.A.:—Annual Report of the Trustees of the Museum of Comparative Zoology at Harvard College, in Cambridge, together with the Report of the Committee on the Museum for 1873.—*The Trustees.*

CARLSRUHE:—Verhandlungen des Naturwissenschaftlichen Vereins in Karlsruhe, 1864 and 1866, 1869, 1871, 1873, and 1876.—*The Society.*

DRESDEN:—General Directorship of Royal Collection for Arts and Science, Dresden—

1. Die Urnenfelder von Strahlen.
2. Geologie von Sumatra.
3. Der Arabische Himmelsglobus.
4. Mittheilungen aus dem Königl. Geologischen Museum.
5. Mittheilungen uber die Sammlungen des Königl. Mathem-Physikal. Salons.
6. Katalog des Sammlungen des Königl. Mathem.-Physikalischen. Salons.

—*The Institution.*

FRANKFURT A M.:—Bericht uber die Senckenbergische Naturforschende Gesellschaft, 1874–75.—*The Society.*

FREIBURG: Berichte der Naturforschenden Gesellschaft. Freiburg, 1870–71–72–73.—*The Society.*

GLASGOW:—The Glasgow University Calendar for the Year 1876–77.—*The University.*

GORLITZ:—Abhandlungen der Naturforschenden Gesellschaft in Gorlitz, 1857, 1860, 1862, 1868, 1871, and 1875.—*The Society.*

HAMBURG:—Geographische Gesellschaft. (Two Reports.)—*The Society.*

HEIDELBERG:—Verhandlungen des Naturhistorisch-Medicinischen Vereins zu Heidelberg. Neue Folge 1, 2, 3.—*The Society.*

HOBART TOWN, Tasmania:—Results of Five Years' Meteorological Obser-vetions for Hobart Town. By Francis Abbott, F.R.A.S.—*The Author.*

Monthly Notices, Royal Society of Tasmania, 1874.—*The Society.*

JENA:—Report from the Society of Natural History in Jena, 1874, 1875, and 1876.—*The Society.*

LONDON:—Proceedings of the Royal Society. Vol. XXIV., Nos. 164, 165, 166, 167, 168, 169.

Ditto. Vols. XXV and XXVI.—*The Society.*

MELBOURNE:—Results of Observations in Meteorology, Terrestrial Magnetism, as taken at the Melbourne Observatory during the year 1874, vol. III., under the direction of Robert L. J. Ellery, Government Astronomer.—*The Observatory.*

Victoria Patents and Patentees. Vol. VIII.—*The Registrar General of Victoria.*

Reports of the Proceedings of the Central Board of Health, Melbourne.—*The Central Board of Health.*

Report of the Chief Inspector of Mines to the Hon. the Minister for Mines, for the year 1875.

Reports of the Mining Surveyors and Registrars, quarter ending 30th June, 1876, Victoria.

—*The Department of Mines.*

Abstracts of Specifications of Patents applied for from 1854 to 1866. —*The Registrar General's Office, Melbourne.*

Geological Sketch Map of Victoria; Geological Sketch Map of the Cape Otway District; Geological Sketch Map of a part of the Mitchell District; Division of the Gippsland Mining District.

MELBOURNE—*continued.*
Geological Map of Ballaarat Gold Field, with Notes and Section.
Do. of Sandhurst.
Do. of Beechworth.
Map showing the Distribution of Forest Trees in Victoria.
Geological Survey of Victoria; Reports of Progress, Nos. I., II., and III.
Prodromus of the Palæontology of Victoria. Decades I, II, and III.
Observations on New Vegetable Fossils of the Auriferous Drifts of Victoria.
Reports of the Chief Inspector of Mines for the years 1874–75.
Mineral Surveyors' and Registrars' Reports for the quarter ending 31st March, 1876.
—*The Hon. the Minister of Mines, on behalf of the Government of Victoria.*
The Statistical Register of the Colony of Victoria for the year 1874. Part VIII—Vital Statistics. Part IX—Religious, Moral, and Intellectual Progress. (Two copies.)
Statistics of Friendly Societies for the year 1874.
Statistical Register of the Colony of Victoria, 1874; General Index; The Government Statist of Victoria; Australian Statistics, 1874; Supplementary Tables.
Agricultural Statistics, 1875–76. (Two copies.)
Statistical Register of Victoria. Parts 1, 2, and 3.
—*The Government Statist of Victoria.*
Mineral Statistics of Victoria for the year 1875. (Two copies.)
Mineral Statistics of Victoria for the year 1875.
—*The Minister for Mines, on behalf of the Government of Victoria.*
Statistical Register of the Colony of Victoria for the year 1875—Part IV—Interchange; Part V—Production; Part VI—Law, Crime, &c.; Part VII—Accumulation. Australian Statistics for the year 1875.—*The Government Statist.*

MOSCOW:—Bulletin de la Société Imperiale des Naturalistes de Moscow. Parts 1 and 2. 1869.

OTAGO, New Zealand:—Report on the Geology and Gold Fields of Otago, by F. W. Hutton, F.G.S., C.M.Z.S., Provincial Geologist, and G. H. F. Ulrich, F.G.S.—*The Provincial Geologist.*

PARIS:—Bulletin de la Société Géologique de France. Troisième Série, tome premier.—*The Society.*
Annuaire de la Sociéte Philotechnique, Année 1875, tome trente-sixième.—*The Society.*

PISA:—Atti della Societa Toscana di Scienze Naturali Ressidente in Pisa. Vol. I, Parts 1 and 2.; Vol. II, Part 1.—*The Society.*

STOCKHOLM:—Meteorologiska Jakttagelser i Sverige. 1873.
Ofversigt af Kongl. Svenska Vetenskaps—Akademiens Förhandlingar. 28 to 31.
Handlingar (Mémoires). 4: 0, Bd. 9. Parts 2, 10 & 12.
Bihang (Supplement aux Mémoires). In 8: 0, H. 1: 1 & 2. 2: 1 & 2.
Lefuadsteckingar. Bd. 1: 3.
Handlingar (Mémoires), in 4to., bd. 11, with 53 Plates (Echinoidees).
Bihang (Supplement aux Mémoires). Bd. 3: 1.
Ofversigt (Bulletin), in 8vo., 1875.
Eugenies Resa Omkring Jorden, 1851–1853. Nos. 13 and 14.—*L'Académie Royale Suédoise de Stockholm.*

SYDNEY:—Progress Reports of the Sydney **Sewage and Health Board.** Parts 1 to 11.

Report on Sydney and Suburban Water Supply. 1 and 2.

An Act for preventing Nuisances, 39 Vic. 14.

Do. do. do. No. 7.

Professor Pell, Chairman of the Sewage and Health Board.

The Blue Book, 1875.—*The Government Printer.*

Annual Report of the Department of Mines, New South Wales, for the year 1875.—*The Hon. the Minister for Mines.*

Government Observatory—Report of Astronomer, 1874–75.—*The Observatory.*

Results of Meteorological Observations made in New South Wales during 1874.—*The Observatory.*

Proceedings of the Linnean Society of New South Wales. Vol. 1, Part 1, and Part 2; with Plates.—*The Society.*

WASHINGTON:—Meteorological Observations durnig the year 1872, in Utah, Idaho, and Montana.—*The Smithsonian Institution.*

Daily Bulletin of Weather Reports for the Month of March, 1873.—*Office of the Chief Signal Officer.*

Reports of Observations of the Total Eclipse of the Sun; with Plates.

Determination of the Astronomical Latitude of a Station by means of the Zenith Telescope.

Determination of the Astronomical Azimuth of a Direction.

Report on the Results from the Observations made at the Magnetical Observatory on Capitol Hill.

The Star Factors—A.B.C., for reducing Transit Observations, 1874.

On the use of the Zenith Telescope for Observations of Time.

Notes on Measurements of Terrestrial Magnetism.

United States Coast Survey Catalogue of Charts, 1875.

Report of the Superintendent of the United States Coast Survey for 1871.

United States Coast Survey Report, 1868. Appendix, No. 10.

Do. do. do. 1869. Appendix, 13.

Do. do. do. 1870. Appendix, 11, 12, 13, 16 19, and 21.

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Do. do. do. 1872. Appendix, 12.

Do. do. do. 1873. Appendix, 12, 13, 14, and 22.

On the use of Railways for Geodetic Surveys.

Special Survey of the Harbour of Province Town, in the State of Massachusetts.

Report on the Tides and Currents of Hell Gate, one of the entrances to New York Harbour.

Scientific Lecture on Tides and Tidal Action in Harbours.

Field Catalogue of 983 Transit Stars.

United States Coast Survey Projection Tables.

Report on Mt. St. Elias.

A Treatise on the Plane Table, and its use in Topographical Surveying.

On the Reclamation of Tide Sands and its relation to Navigation.

Memoranda relating to the Field Work of the Secondary Triangulation.

Reports concerning Martha's Vineyard and Nantucket.

Cape Cod Ship Canal Report.

WASHINGTON—*continued.*

On the Air contained in Sea Water.
—*The United States Coast Survey Office.*

Coasts and Islands of the Mediterranean Sea, Part I.—*The Bureau of Navigation.*

Coasts and Ports of the Bay of Biscay, No. 60. Hydrographic Office, U.S. Navy.—*The Bureau of Navigation.*

Annual Report of the Board of Regents of the Smithsonian Institution for the year 1873.

Daily Bulletin of the Signal Service, U.S. of America, January and February, 1873.

Report of the U.S. Geological Survey of the Territories, Vol. VI. Cretaceous Flora; with Plates.

Catalogue of the Publications of the United States Geological Survey of the Territories, by F. V. Hayden, Geologist-in-charge, 1874.

Chronological Observations on Introduced Animals and Plants, Part 1.

List of Elevations, principally in that portion of the United States west of the Mississippi River.

Report on the Chemistry of the Earth, by T. Sterry Hunt, LL.D., F.R.S. (Two copies.)

Memoir of C. F. P. von Martius, by Chas. Rau. (Two copies.)

Contributions to the Ichthyology of the Western Coast of the United States, from specimens in the Museum of the Smithsonian Institution. (Two copies.)

Bulletin of the United States Geological Survey of the Territories, No. 2.

Synopsis of the Flora of Colorado, by Chas. C. Porter and John M. Coulter.
—*The Smithsonian Institution.*

Professional Papers, Corps of Engineers:—
No. 6. Casemate Embrasures—Totta; with Maps.
No. 7. Stability of Arches—Woodbury.
No. 12. Tables and Formulæ—Lee.
No. 22. North Sea Canal of Holland—Barnard; with Plans.

Reconnaisance of the Yukan River, by Capt. C. W. Raymond.

Reconnaissance of the Ute Country, by Lieut. E. H. Ruffner; with Map.

Physical Features of the Valley of the Minnesota River. G. K. Warren. With Maps.

Explorations in Nebraska and Dakota in the years 1855–56–57; with Maps.

Reconnaisance of the Black Hills. Wm. Ludlow. With Maps.

Expedition up the Yellow-stone River—Forsyth Grant; with Map.

Geographical Explorations west of the 100th Meridian, by Lieut. G. M. Wheeler, viz.:—

Progress Report upon Geographical and Geological Explorations and Surveys west of the 100th Meridian, in 1872; with Plates.

Ornithological Specimens, 1871–2–3.

Catalogue of Plants, 1871–2–3.

Invertebrate Fossils, 1871–2–3.

Systematic Catalogue of Vertebrate of the Eocene of New Mexico, 1874.

Construction of the Potomac Aqueduct, Turnbull; with Plans.

Removal of Blossom Rock, San Francisco Harbour; with Plates.

Irrigation in California; with Plates.

WASHINGTON—*continued.*

Compressive strength of Building Stone, Gillmore.

Report of the Reclamation of the Alluvial Basin of the Mississippi River; with Plates.

—*The Office of the Chief of Engineers.*

A Sketch of the services of the late Mr. W. Seaton.

The Scientific Education of Mechanics and Artisans.

Report of Explorations in 1873, of the Colorado of the West and its Tributaries.

Thoughts on the nature and origin of Force, by W. B. Taylor.

Annual Report of the Board of Regents of the Smithsonian Institution for the year 1874.

—*The Smithsonian Institution.*

Reports of the Department of Agriculture for 1872–73–74.

Monthly Reports of the Department of Agriculture for 1872–73–74.

—*The Department.*

Report of the Smithsonian Institution, 1874.

Report of Explorations in 1873 of the Colorado of the West and its Tributaries. (Two copies.)

Memoirs of the American Association for the advancement of Science. Vol. I.

Revision of the hitherto known Species of the genus Chionobas in North America, by Saml. H. Scudder.

Entomological Notes by S. H. Scudder, 1, 2, 3, and 4.

Annual Report of the Trustees of the Museum of Comparative Zoology, 1874.

Thoughts on the nature and origin of Force, by W. B. Taylor.

Distribution of Insects in New Hampshire.

Historical Sketch of the generic names proposed for Butterflies, by Saml. H. Scudder.

The Structure and transformation of Eumæus Atala.

Memoirs of the Boston Society of Natural History. Vol. II, Part III, No. IV.

Notes on the Stridulation of some New England Orthoptera.

Notice of some North American Species of Pieris.

Note sur l'Œuf et le Jeune Age de Chenille d'Œncis aello.

—*The Smithsonian Institution.*

The Two Principal Groups of Urbicolæ Tentamen determinationis di Lepidoptera.

Maps of Indian Territory—Ruffner.
Do. do. Jackson.
Do. Montana.
Do. New Mexico and Arizona.
Do. New Mexico—Ruffner.
Do. do. Morrison.
Do. Nebraska and Dakota.
Do. Dakota.
Do. Western Territories and Northern Extension.
Do. Kansas, Texas, &c.
Do. Part of Nebraska.
Do. do.
Do. do. and Wyoming.
Do. do.
Do. do.
Do. do.
(the six "Part of Nebraska" maps above: Jones.)
Do. Middle and Eastern Tennessee.
Do. S. and S.E. Nevada.

WASHINGTON—*continued.* *Ute Country.*

Maps of Wheeler's Atlas (Explorations, west 100th Meridian).
Do. Yellow Stone Lake, &c.
Do. Yellow Stone and Missouri Rivers, &c.
Do. U.S. Military Map.
Do. San Domingo.
Do. Florida.
—*The Office of the Chief of Engineers.*

WELLINGTON:—Tenth Annual Report of the Colonial Museum and Laboratory, together with a list of Donations and Deposits during 1874–75.—*The Colonial Museum.*

Transactions and Proceedings of the New Zealand Institute, 1875. Vol. VIII.—*The Institute.*

MISCELLANEOUS.

(Names of Donors in small capitals.)

BARKAS, W. J., L.R.C.P., London.
List of Palæozoic Fishes. By W. J. Barkas.
On the Microscopical Structure of Fossil Teeth from the Northumberland True Coal Measures.—*Idem.*

BENSUSAN, L. S.
Proceedings of the Geological Society. Vols. 2 and 3.
Quarterly Journal of the Geological Society. 13 Nos.
Proceedings of the Royal Society, London. 40 Nos.

BLEASDALE, REV. DR.
An Essay on the Wines sent to the late Intercolonial Exibition, of the Colonies of Victoria, New South Wales, and South Australia.
Philadelphia Centennial Exhibition of 1876. (Melbourne, 1875.) Official Record.

BRAZIER, JOHN, C.M.Z.S.
Description of eleven new species of Terrestrial and Marine Shells from North-east Australia. By J. Brazier, C.M.Z.S.
Description of ten new species of Shells from the collection of Mr. Chas. Dixon of Brisbane, Queensland.—*Idem.*

DIXON, W. A., F.C.S.
C. Plinny Historiæ Mundi.
Tables of Quantitative Analysis, arranged for the use of Students, By W. A. Dixon, F.C.S.

Dr. P. L. HATCH, United States:—Constitution and By-laws of Minnesota Academy of Natural Sciences—1873.
Bulletin of the Minnesota Academy of Natural Sciences—1874.

LIVERSIDGE, PROFESSOR ARCHIBALD, F.C.S.
Statistical Register of New South Wales—1874.
Catalogue of the Minerals and Rocks in the collection of the Australian Museum, by Gerard Krefft, F.L.S.
Map of New South Wales (mounted and varnished).
Victorian Intercolonial Exhibition—1875, preparatory to the Philadelphia Exhibition—1876 Official Catalogue.
Official Catalogue of the natural and industrial Products of New South Wales, forwarded to the International Exhibition of 1876, Philadelphia.
Cave-hunting, by W. Boyd Dawkins.
Darwin's Naturalist's Voyage.
Nicol's Mineralogy.
Disease in the Sugar-cane, Queensland. By Professor Liversidge.

MACLAY M. VON (Batavia).
Ueber Brachyocephalität bei den Papuas von New Guinea.—*The Author.*
Ethnologische Bermerkungen ueber die Papuas der Maclay—Kusti in New Guinea. By M. von Maclay.—*Idem.*
Anthropologische Bemerkungen neber die Papuas der Maclay, Kuste in New Guinea.—*Idem.*
An Ethnological Excursion in Johore.—*Idem.*
MULLER, BARON FREDK. VON, C.M.G.
Descriptive Notes on Papuan Plants. By Baron von Müller.
Fragmenta Phytographiæ Australiæ. Vol. 9. By Baron von Müller.
Descriptive Notes on Papuan Plants. By Baron von Müller.
Descriptive Notes on Papuan Plants. Parts I and II. By Baron von Müller.
OSBORNE, JAMES. (Wollongong.)
Royal Gallery of British Art.
Grammar of Ornament. By Owen Jones.
RAMSAY, EDWARD P., F.L.S., C.M.Z.S.
Catalogue of the Australian Birds in the Australian Museum, at Sydney, New South Wales. Part 1, Accipitres. By E. P. Ramsay.
List of Birds met with in North-eastern Queensland, chiefly at Rockingham Bay. By E. P. Ramsay, F.L.S.
Notes on the original Specimen of Ptilonorhynchus Rawnsleyi.—*Idem.*
REID, GEORGE H.
A Free Trade Essay. By G. H. Reid. (Five copies.)
RIDLEY, REV. WM.
Kámilarói and other Australian Languages. By W. Ridley, M.A.
ROBERTS, ALFRED.
Quarterly Journal of Microscopic Science. 19 vols.
Sixteen Pamphlets on Diatoms.
RUSSELL, H. C., B.A., F.R.A.S.
Notes on the Climate of Victoria. By R. L. J. Ellery.
Photograph and Key of Scientific Celebrities (German).
SCHOMBURG, DR. R.
The Flora of South Australia. By Dr. Schomburg.
Report on the Progress and Condition of the Botanic Garden and Government Plantations during the year 1874. (Two copies.)—*Idem.*
Report on the progress and condition of the Botanic Gardens and Government Plantations during the year 1875.
Botanical Reminiscences in British Guiana.—*Idem.*
THURSTON, F. T., Civil and Mechanical Engineer. (Hoboken, N. J.)
On the Economy resulting from Expansion of Steam. By Robt. H. Thurston.
On the Thermal and Mechanical Properties of Air and other permanent Gas.
Iron Manufactures in Great Britain. By R. H. Thurston.
Bessemer Machinery.
Report of the Committee appointed to test Steam Boilers at the American Institute Exhibition.
Molecular Changes in Metals. (Two copies.)
Molecular Changes produced in Iron by variations of temperature.
Modern Industrial Progress and the Influences accelerating its march. By F. A. P. Bernard, LL.D., L.H.D.
A new Marine Signal Light. (Two copies.)

THURSTON, F. T.—*continued.*

The Theory of Aero-Steam Engines.
Annual announcement of the Stevens Institute of Technology.
Inland Transportation.
Experimental Steam Boiler Explosions.
H.B.M. Iron-clad "Monarch."
The Westfield Steamer Boiler Explosion.
Tensile Strength of American and English Iron and Steel.
A Paper relating to Traction Engines.
The Messrs. Stevens, of Hoboken, as Engineers, Naval Architects, and Philanthropists.
Letter to the Hon. Geo. M. Robeson, Secretary to the United States Navy.
Strength combined with economy of material in constructing the details of Steam-engines. (Two copies.)
Stevens' Battery, 1874.
On the losses of propelling power in the Paddle-wheel.
Steam Engines of the French Navy.
Transmission of Motion.
On the Strength, Elasticity, Ductility, and Resilience of Materials of Machine construction.

W. WHITAKER, B.A., F.G.S.

Remarks on the Australian Gold Fields, by W. S. Jevons.
On Subarial Denudation, and on Cliffs and Escarpments of the Chalk and Lower Tertiary Beds. By W. Whitaker, B.A., F.G.S.

WOODS, REVD. J. E. T., F.G.S.

On a New Genus of Nudibranchiata. By J. Tenison Woods.

SCIENTIFIC PERIODICALS SUBSCRIBED FOR.

American Journal of Science and Art.
Annals of Natural History.
Botanical Journal (Trimen.)
British Association—Annual Reports.
Chemical News.
Comptes Rendus.
Dingler's Polytechnische Journal.
Encyclopædia Britannica—new edition—half-bound in Russia (5 vols.); as issued.
English Mechanic and Mirror of Science.
Fresenius' Zeitschrift für Analytische Chemie.
Geological Magazine.
Geological Record.
Journal of the "Geological Society," London.
Journal of the "Geological Society," France.
Journal of the "Chemical Society," London.
Journal of the "Linnean Society," London.
Journal of the "Physical Society," London.
Journal of the "Royal Microscopical Society," London.
Nature.
Philosophical Magazine.
Proceedings of the "Geological Association," London.
Proceedings of the "Manchester Geological Society."
Publications of the "Palæontographical Society," London.
Publications of the "Royal Geological Society," Cornwall.
Quarterly Journal of the "Meteorological Society."

DONATIONS TO THE SOCIETY'S CABINET OF MICROSCOPICAL OBJECTS, &c., 1876.

BROWN, H. J. (Newcastle.)
Slides of Spiculæ.

HIRST, J. D.
Slide of Polyzoa, Port Jackson; Section of Schirrhus Cancer. Drawings of *Drosera binata*.

MACDONNELL, W.
12 slides of Foramenifera.

PATERSON, HUGH.
Slide containing section of Human Tooth, and slide of Tooth showing exostosis.

ROBERTS, A., M.R.C.S.
36 slides of Diatoms, mounted, by Dr. Smith, of Edinburgh.
Slides of Foramenifera, by Möller.

WOODGATE, E.
Slide of Salicine Crystals, and section of Elder-pith.

DONATIONS

FROM THE

ROYAL SOCIETY OF NEW SOUTH WALES.

No. 1.—Transactions of the Royal Society of New South Wales, 1875.
„ 2.—Transactions of the Philosophical Society, 1862–65.
„ 3.—Mineral Map and Statistics.
„ 4.—Resources of New South Wales.
„ 5.—Mines and Mineral Statistics.
„ 6.—Meteorological Report, 1873.

[In the following list the numbers refer to the above-mentioned publications.]

Austria.

Vienna.—Kaiserlich Akademie der Wissenchaften. Nos. 1, 2, 3, 4, and 5.
„ Zoological and Botanical Society. Nos. 1, 2, 3, 4, and 5.

Belgium.

Brussels.—Académie Royale des Sciences. Nos. 1, 2, 3, 4, 5, and 6.

The Dominion of Canada.

Montreal.—Geological Survey of Canada. Nos. 1, 2, 3, 4, and 5.
Halifax.—Natural History Society of Montreal. Nos. 1, 2, 3, 4, and 5.

England.

Cambridge.—The Philosophical Society. Nos. 1, 2, 3, 4, 5, and 6.
„ The Ray Club. Nos. 1, 2, 3, 4, 5, and 6.
„ The Natural Science Club. Nos. 1, 2, 3, 4, 5, and 6.
„ The University Library. Nos. 1, 2, 3, 4, and 5.
„ The Public Library. Nos. 1, 2, 3, 4, 5, and 6.

Leeds.—The College of Science. Nos. 1 to 5.

London.—The Anthropological Society. Nos. 1, 2, 3, 4, and 5.
„ The British Association. Nos. 1 to 5.
„ The British Museum. Nos. 1 to 5.
„ The Chemical Society, Burlington House. Nos. 1, 2, 3, 4, and 5.
„ The Geological Society, Burlington House. Nos. 1, 2, 3, 4, 5, and 6.
„ The Linnean Society, Burlington House. Nos. 1, 2, 3, 4, and 5.
„ The Meteorological Society. No. 1.
The Physical Society, South Kensington Museum. Nos. 1, 2, 3, 4, 5, and 6.

London.—The Royal Asiatic Society. Nos. 1, 2, 3, 4, and 5.
„ The Royal Astronomical Society. No. 1.
„ The Royal Colonial Institute. Nos. 1, 2, 3, 4, and 5.
„ The Royal Geographical Society. Nos. 1 to 6.
„ The Royal Society, Burlington House. Nos. 1, 2, 3, 4, 5, and 6.
„ The Royal School of Mines. Nos. 1, 2, 3, 4, 5, and 6.
„ The Society of Arts. No. 1 to 6.

Manchester.—The Geological Society. Nos. 1, 2, 3, 4, 5, and 6.
„ The Owen's College. Nos. 1 to 6.

Middlesborough.—The Iron and Steel Institute. Nos. 1 to 5.

Oxford.—The Radcliffe Library. No. 1 to 5.
„ The Bodleian Library. No. 1 to 5.
„ The University Library. No. 1 to 5.

Penzance.—Royal Geological Society of Cornwall. Nos. 1 to 5.
Truro, Cornwall.—The Mineralogical Society of Great Britain and Ireland. Truro. Nos. 1, 2, 3, 4, 5, and 6.

Ireland.

Dublin.—The Royal Irish Academy. Nos. 1, 2, 3, 4, and 5.

Scotland.

Edinburgh.—The Royal Society. Nos. 1, 2, 3, 4, 5, and 6.

France.

Paris.—Société Philotechnique. Nos. 1, 2, 3, 4, 5, and 6.
„ The Academy of Sciences. Nos. 1, 2, 3, 4, 5, and 6.
„ The Anatomical Society. Nos. 1, 2, 3, 4, 5, and 6.
„ The Anthropological Society. Nos. 1, 2, 3, 4, 5, and 6.
„ The Biological Society. Nos. 1, 2, 3, 4, 5, and 6.
„ The Chirurgical Society. Nos. 1, 2, 3, 4, 5, and 6.
„ The Dean of the Faculty of Medicine. Nos. 1, 2, 3, 4, 5, and 6.
„ The Director of the Museum of Natural History. Nos. 1, 2, 3, 4, 5, and 6.
„ The Entomological Society. Nos. 1, 2, 3, 4, 5, and 6.
„ The Geographical Society. Nos. 1, 2, 3, 4, 5, and 6.
„ The Geological Society. Nos. 1, 2, 3, 4, 5, and 6.
„ The Mineralogical Society. Nos. 1, 2, 3, 4, 5, and 6.

Italy.

Pisa.—Societa Toscana di Scienza Naturale. Nos. 1 to 5.

India.

Calcutta.—The Geological Survey of India. Nos. 1, 2, 3, 4, and 5.

Scientific Institutions of Germany.

Berlin.—Königliche Akademie der Wissenchaften. Transactions of the Royal Society of New South Wales. 1867–75, and Nos. 2, 3, 4, 5, and 6. (14 vols.)

Bonn.—Naturhistorische Verein der Pruessischen Rheinlande und Westphalens in Bonn. Transactions of Royal Society of New South Wales. 1868–75, and Nos. 2, 3, 4, 5, and 6. (13 vols.)

Carlsruhe.—Naturwissenschaftlicher Verein zu Carlsruhe. Nos. 1, 2, 3, 4, and 5.

Dresden.—General Direction der Königliche Sammlungen für Kunst and Wissenchaft zu Dresden. Transactions of the Royal Society of New South Wales. 1868–75, and Nos. 2, 3, 4, 5, and 6. (13 vols.)
" Das Statistische Büreau des Ministeriums des Innern zu Dresden. Nos. 1, 2, 3, 4, 5, and 6.
" Die Kaiserlich Leopoldinisch-Carolinisch Deutsche Akademie der Naturforscher zu Dresden. Nos. 1, 2, 3, 4, 5, and 6.

Frankfurt a/M.—Senckenbergische naturforschende Gesellschaft in Frankfurt a/M. Nos. 1, 2, 3, 4, and 5.

Freiberg.—Die Berg Akademie zu Freiberg. Nos. 1, 2, 3, 4, and 5
" Naturforchende Gesellschaft zu Freiberg. Nos. 1, 2, 3, 4, and 5.

Göttingen.—Königliche Gesellchaft der Wissenchaften in Göttingen. Nos. 1, 2, 3, 4, and 5.

Görlitz.—Naturforschende Gesellschaft in Gözlitz. Nos. 1, 2, 3, 4, and 5.

Hamburg.—Die Geographische Gesellschaft in Hamburg. Nos. 1, 2, 3, 4, and 5.

Heidelburg.—Naturalhistorisch Medicinische Gesellschaft zu Heidelberg. Nos. 1, 2, 3, 4, and 5.

Königsberg.—Die Physikalisch-occonomische Gesellschaft in Königsberg, (Pn.) Nos. 1, 2, 2, 3, 4, 5, and 6.

Marburg.—The University, Marburg. Nos. 1, 2, 3, 4, 5, and 6.

Munich.—Königliche Akademie der Wissenschaften in München. Nos. 1, 2, 3, 4, and 5.

Stuttgart.—Königlich Statistich-Topographische Büreau zu Stuttgart. Nos. 1, 2, 3, 4, and 5.

Wurttemburg.—Der Verein für Vaterlandische Naturkunde in Wurttemburg. Transactions of Royal Society of New South Wales. 1867–75, and Nos. 2, 3, 4, 5, and 6. (14 vols.)

Russia.

St. Petersburg.—Académie Imperiale des Sciences. Nos. 1, 2, 3, 4, 5, and 6.

Sweden.

Stockholm.—L'Acad. Roy. Suedoise. Nos. 1 to 5.

Switzerland.

Geneva.—Société de Physique et d'Histoire Naturelle. Nos. 1, 2, 3, 4, 5, and 6.

Lausanne.—Société Vaudoise des Sciences Naturelles. Nos. 1, 2, 3, 4, and 5.

Neuchatel.—Société des Sciences Naturelles. Nos. 1, 2, 3, 4, and 5.

UNITED STATES.

Albany.—New York State Library, Albany. Nos. 1, 2, 3, 4, 5, and 6.

Baltimore.—John Hopkins' University. Nos. 1, 2, 3, 4, 5, and 6.

Boston.—Boston Society of Natural History. Nos. 1, 2, 3, 4, 5, and 6.
„ American Academy of Sciences. Nos. 1, 2, 3, 4, 5, and 6.

Cambridge.—The Museum of Comparative Zoology, Harvard College. Nos. 1, 2, 3, 4, 5, and 6.

Minneópolis.—Minesota Academy of Natural Science. Nos. 1, 2, 3, 4, 5, and 6.

New York.—Lyceum of Natural History. Nos. 1, 2, 3, 4, 5, and 6.
„ School of Mines, Columbia College. Nos. 1, 2, 3, 4, and 5.

Philadelphia.—American Entomological Society. Nos. 1, 2, 3, and 4.
„ American Philosophical Society. Nos. 1, 2, 3, 4, and 5.
„ Academy of Natural Science. Nos. 1, 2, 3, 4, and 5.
„ Franklin Institute. Nos. 1, 2, 3, 4, 5, and 6.

Washington.—Dr. F. V. Hayden, Geological Survey of Territories. Nos. 1, 2, 3, 4, and 5.
„ Hydrographic Office. Nos. 1, 2, 3, 4, 5, and 6.
„ War Department. Nos. 1, 2, 3, 4, 5, and 6.
„ Commissioner for Agriculture. Nos. 1, 2, 3, 4, 5, and 6.
„ Smithsonian Institute. Nos. 1, 2, 3, 4, 5, and 6.

INTERCOLONIAL.

CAPE OF GOOD HOPE.

Cape Town.—The Philosophical Society. Nos. 1, 2, 3, 4, 5, and 6.

MAURITIUS.

Port Louis.—The Royal Society of Arts and Sciences. Nos. 1 to 6.

NEW SOUTH WALES.

Sydney.—The University of Sydney. No. 1.
„ The Linnean Society of New South Wales. No. 1.
„ The Mining Department. No. 1.
„ The Free Public Library. No. 1.
„ The Observatory. No. 1.

NEW ZEALAND.

Auckland.—Auckland Institute. No. 1.

Christchurch.—Canterbury Institute. No. 1.

Otago.—Otago Institute. No. 1.

Wellington.—New Zealand Institute. No. 1.

QUEENSLAND.

Brisbane.—The Philosophical Society. No. 1.

SOUTH AUSTRALIA.

Adelaide.—The Adelaide University. Transactions of the Royal Society of New South Wales. 1867 to 1875, and Nos. 2, 3, 4, 5, and 6. (14 vols.)
„ The South Australian Institute. No. 1.

TASMANIA.

Hobart Town.—The Royal Society of Tasmania. No. 1.

VICTORIA.

Melbourne.—The Free Public Library. No. 1.
" The Melbourne University. No. 1.
" The Government Statist. No. 1.
" The Royal Society of Victoria. No. 1.
" The Mining Department. No. 1.
" The Observatory.

Papers and Periodicals.

American Journal of Science and Arts, New Haven, Conn. Nos. 1, 2, 3, 4, 5, and 6.
Argus, Melbourne, Victoria. No. 1.
Colonist, London. No. 1.
Evening News, Sydney. No. 1.
Geological Magazine, London. No. 1.
Geological Record, London. No. 1.
Nature, London. No. 1.
Quarterly Journal of Science. No. 1.
Sydney Morning Herald. No. 1.
Westminster Review, London. No. 1.

SUMMARY OF NUMBER OF PUBLICATIONS DISTRIBUTED BY THE SOCIETY IN THE YEAR 1876.

10	to Austria.
6	" Belgium.
10	" Canada.
161	" Great Britain and Ireland.
72	" France.
5	" Italy.
5	" India.
128	" Germany.
6	" Russia.
5	" Sweden.
16	" Switzerland.
96	" United States.
44	" Colonies.
15	" Periodicals and papers (for review).
Total—579	

REPORTS FROM THE SECTIONS
(IN ABSTRACT).

REPORTS FROM THE SECTIONS.

(In Abstract.)

SECTION A.—ASTRONOMY AND PHYSICS.

PRELIMINARY MEETING—MONDAY, 19 JUNE, 1876.

In accordance with Rule XXIX of the Society's new Bye-laws, a meeting was held in the Society's rooms, on Monday, 19th June, 1876, to organize a Section for Astronomy, Meteorology, Physics, Mathematics, and Mechanics, the following gentlemen being present:—

Mr. H. C. Russell, F.R.A.S., in the Chair.

Mr. Bolding,
Rev. W. B. Clarke, F.R.S., &c.,
Mr. J. U. C. Colyer,
Mr. J. V. Dalgarno,
Hon. L. F. De Salis, M.L.C.,
Mr. E. Du Faur, F.R.G.S.,
Mr. G. D. Hirst,
Mr. H. A. Lenehan,
Dr. Leibius,
Prof. A. Liversidge,
Mr. W. MacDonnell,
Mr. W. J. MacDonnell, F.R.A.S.,
Mr. W. H. Maguire,
Rev. W. Scott, M.A.
Mr. Voss.

It was resolved that the Section be formed, and the following office-bearers were appointed for the current session:—Chairman, Mr. H. C. Russell, B.A., F.R.A.S., &c.; Hon. Secy., Mr. W. J. MacDonnell, F.R.A.S.; Committee, Mr. G. D. Hirst, Mr. H. A. Lenehan, Rev. W. Scott, M.A., and Mr. H. G. A. Wright, M.R.C.S.

The Chairman, after stating that Astronomy was likely to prove the chief object of attraction, drew the attention of the Section to the requisition made by the Royal Astronomical Society of London, for co-operation of southern astronomers in the work of observing the planet Jupiter during his present favorable opposition, and Mr. Russell recommended the Section to take up this work as far as possible.

Mr. Hirst gave some particulars of his observations on Jupiter, remarking the great difference in the colours of the equatorial belt as seen in different classes of telescope. In the Observatory *refractor* of 11½ inches aperture the colour of the belt was pink, and in Mr. Colyer's 10½-inch Browning *reflector* used by him, it was ochreish-yellow.

Hon. L. F. De Salis, M.L.C., referred to a periodicity apparent in the recurrence of meteorological phenomena in this Colony, and promised to return to the subject at greater length at next meeting of the Section. Mr. E. Du Faur, in supporting Mr. De Salis's view, instanced the remarkable changes that have been observed in Lake George, as an example of the periodicity theory advanced by Mr. De Salis. After further discussion the meeting terminated.

WEDNESDAY, 26 JULY, 1876.

Mr. H. C. Russell, F.R.A.S., in the Chair.

Hon. L. F. De Salis, M.L.C., read a paper on "Lunar Influence on the Weather and Periodicity of the Seasons." He stated that scientific investigation into the causes which control the weather was one of high practical utility to the Colony, and was well deserving of the Section's attention. Throughout recent scientific works there are several assertions that periodicity has been traced in important weather changes around the Mauritius, coincident with the periodic changes that take place in the sun. After suggesting that lunar influence was not a fable of olden times, and referring to Saxby's theories, which however were not generally accepted by the late Admiral Fitzroy and men of his calibre, Mr. De Salis remarked from his own observations during a colonial lifetime that our winds veered round in direction contrary to the cyclonic rule, during a period equalling in time a quarter lunation. Mr. De Salis referred to several instances where this rule was apparently confirmed. He also noticed that besides this monthly influence there was one traceable to the lunar cycle of 19 years or its half period of 9½ years when the moon's position was analogous to the changes at full and new in the ordinary lunation of 29 days. He pointed out that the floods on the Murrumbidgee in 1844, 1852–3, 1861–2, and 1870–1–2, were in strong confirmation of the existence of this period. A co-operation in the observation of Australian climatology was strongly urged, and the example of the United States expending £300,000 on Meteorology was quoted as being worthy of imitation. A proportionate sum for the united Australian Colonies would only amount to £20,000.

In the discussion which followed the reading of Mr. De Salis's paper,—

Mr. Russell said he had given the matter great attention; he formerly advocated the 19 year period, and had afterwards abandoned it; but recent facts in confirmation had so pressed themselves upon him that he felt compelled to adopt the theory once more.

After further discussion the meeting terminated.

Eleven members were present.

WEDNESDAY, 30 AUGUST, 1876.

Mr. H. C. RUSSELL, F.R.A.S., in the Chair.

In answer to a question made by one of the members present, Mr. RUSSELL described some of the methods adopted in the manufacture of optical glass as noticed by him in his recent visit to Europe and America. He also explained the beautifully delicate apparatus invented by the Hamburgh optician, Mr. H. Schrœder, for testing the curves of telescope lenses with an accuracy previously unknown.

The Chairman then read some notes he had prepared on the planet Venus. The white patch visible during the transit of December, 1874, was again detected on 15th June, 1876. On several occasions part of the disc was visible in the telescope; the dark portion being apparently projected upon a lighter back ground of sky. On 30th June, Mr. Russell, in observing Jupiter's satellites with a power of 800, noticed that the third satellite was of a ruddy colour and sharply defined disc. A mean of 46 micrometrical measure gave a polar flattening to Jupiter of 1–17·5.

WEDNESDAY, 27 SEPTEMBER, 1876.

Mr. H. C. RUSSELL, F.R.A.S., in the Chair.

Mr. G. D. HIRST exhibited a drawing of Saturn executed from a $10\frac{1}{4}$-inch silvered glass equatorial with a power of 214. He remarked the square-shouldered appearance of the ball of the planet noticed by former observers. The most remarkable feature on the ball was a dark belt near the equator of a rich brown inclining to red; the black line in the centre of this belt, first noticed by Mr. Russell a couple of years ago, was not visible in the reflector. The poles of the planet exhibited a beautiful bluish-grey, shading off into a yellow towards the equator. Ball's division in the ring was only visible at the two extremities. The crape ring appears as a remarkably dark band crossing the disc of the planet.

Mr. RUSSELL stated that the narrow black line indicating the shadow of the ring on the ball appeared a short time ago perfectly straight instead of following the outline of the ring; a micrometer laid along it showed no deviation.

A discussion followed relative to the gale of 10th September, as compared with tropical tornadoes, Mr. Du Faur remarking that from his experience within the tropics the velocity of the wind in the late gale, although very high, must have fallen far short of what it attained during West Indian hurricanes. The discussion then turned to some of the meteorological characteristics of this Colony. Messrs. De Salis and Du Faur gave some particulars of important changes produced in the configuration of the country by floods in the interior.

The meeting then closed.

WEDNESDAY, 25 OCTOBER, 1876.

Mr. H. C. RUSSELL, F.R.A.S., in the Chair.

Mr. COLYER read a letter from Mr. J. Browning, the well-known London optician, relative to the variation in the colour of the equatorial belts of the planet Jupiter when observed through refracting or reflecting telescopes. The question as to which class of instruments gave the most correct results was a difficult one to decide; the Chairman wished that those members in possession of adequate means should take the matter in hand, so that if any law of variation exists it might be brought to light.

Mr. DU FAUR informed the Chairman that he had been in correspondence with some gentlemen in the far interior who were willing to take meteorological observations if instruments for that purpose were supplied to them. Mr. Russell said he had also been taking steps in the same direction, so that regular observations of the climatology of the interior could be taken.

Mr. RUSSELL then read a long paper from Mr. Jones, of Tamworth, on an extraordinary dry fog observed in the neighbourhood of Tamworth, on the morning of 12th October. Mr. De Salis had noticed a somewhat similar phenomenon in 1851, which was ascribed to the prevalence of extensive bush fires then raging in Victoria, but whether the Tamworth dry fog could be traced to a similar origin required further evidence before it could be decided.

WEDNESDAY, 29 NOVEMBER, 1876.

Mr. H. C. RUSSELL, F.R.A.S., in the Chair.

Rev. GEO. MARTIN read a long and interesting paper on the performance of his "Cooke" telescope of 5 inches clear aperture, 6 feet 3 inches focal length. He succeeded in resolving the globular cluster ω. Centauri, with the exception of the central condensation, also the clusters 47 Toucani and 13 M. Herculis. In the resolution of these objects, Mr. Martin found that the light-grasping power of his instrument approached very nearly to its theoretical value. For definition he had tried the capacity of his object glass on Antares, Nu (ν) Scorpii, η Orionis, γ Centauri, all of which difficult doubles he succeeded well in resolving. After referring to other work performed by his telescope, Mr. Martin spoke of the example of Mr. Burnham, of Chicago, in reaping a harvest in fields where Herschel, Struve, and other eminent observers had been working, and he stated that our southern heavens present a splendid field for investigation for any competent observer armed with moderate means and a little patience, in which he would meet with a rich and ample reward.

A short discussion ensued on Mr. Martin's paper.

SECTION B.—CHEMISTRY, MINERALOGY, and by amalgamation with SECTION C., GEOLOGY and PALÆONTOLOGY.

PRELIMINARY MEETING—20 JUNE, 1876.

THE preliminary meeting of this Section was held on 20th June, 1876, when PROF. LIVERSIDGE was appointed Chairman of the Section, W. A. DIXON Hon. Secretary, and Messrs. BENSUSAN, M'CUTCHEON, SLEEP, and TULLOH a Committee; and the meeting night for the Section was fixed for the second Wednesday of each month.

WEDNESDAY, 12 JULY, 1876.

PROFESSOR LIVERSIDGE in the Chair.

The proposal to temporarily amalgamate Section C. with this Committee was agreed to at this meeting.

Mr. DIXON read a note on some analysis of mud from George and Pitt Streets, showing that the amount of organic matter varied from 18 to 55 per cent. of the dried mud, and that the proportion of inorganic matter (*i.e.* abraded stone and iron) to organic matter rose in proportion to the wetness of the streets. He said that although little reliance could be placed on results obtained from three or four analyses, the numbers he had obtained showed that, taking 100 parts of organic matter (horse-dung) to represent a certain amount of traffic, 407 parts of stone were ground up when the streets were kept copiously watered, whilst 66 parts only of stone were pulverized by that traffic when the streets were only slightly sprinkled with water. The results approximated to those obtained by Dr. Letheby from London street mud, which showed that wet weather largely increased the quantity of abraded stone and wear of the streets.

Mr. BENSUSAN introduced to the notice of the meeting the new work on Pyrology, by Major Ross, containing new methods of blowpipe analysis. The Chairman exhibited a case containing specimens of the rare metal, Thallium, and a number of its salts.

WEDNESDAY, 9 AUGUST, 1876.

PROFESSOR LIVERSIDGE in the Chair.

Mr. BENSUSAN exhibited a specimen of the new alloy, composed of copper 88 per cent., tin 10 per cent., and manganese 2 per cent., proposed to be used for armour-plating and other purposes. The specimen he had himself prepared, and he explained that its peculiar excellence consisted in its superior toughness, and to the fact that a shot punched a hole in the plates without rending them.

An interesting conversational discussion upon *Chemical* matters was maintained for some time.

WEDNESDAY, 13 SEPTEMBER, 1876.

Mr. M'Cutcheon in the Chair.

Mr. Bensusan exhibited specimens of native bismuth from New England; a mineral from near Rockhampton containing gold, nickel, and copper; an earthy mineral containing cobalt; elaterite from near Nattai; also carbonate and native copper. He also read his paper on recent copper-extracting processes, which was afterwards read before the Society.

WEDNESDAY, 8 NOVEMBER, 1876.

Professor Liversidge in the Chair.

Mr. Sleep exhibited specimens of *Ancyloceras gigas* and *Scaphites*, from the Flinders River, Queensland.

Professor Liversidge laid on the table specimens of tin ore in a "cement" matrix sent to him by Mr. Cadell, from Vegetable Creek, New England, accompanied by a letter, in which Mr. Cadell said, "I think the difference between 'black' and 'ruby' tin ore can now be accounted for, the discovery having been made accidentally on our claim. You are aware that all our *deep lead* carries black tin, the surface claims only producing 'ruby.' Over some portions of our deposit (deep lead) we have found quantities of ore cemented into one compact mass by oxide of iron. This Mr. O'Daly tried to reduce by burning, and while hot throwing cold water over the heap thus burnt. A large quantity became in this way pulverized, but the process changes the 'black' into 'ruby' tin. I send you specimens showing the cemented deposit before and after being calcined." The Chairman (Prof. Liversidge) pointed out that there were many essential differences between the more or less transparent native "ruby" tin and the brick-coloured calcined mineral. The members present, after examining the specimens, came to the conclusion that the red colour produced was not a conversion of "black" into true "ruby" tin, but merely the change of the ferrous oxide present into anhydrous ferric oxide.

Mr. Dixon laid on the table a specimen of a white earthy mineral sent to him by Mr. Chambers, of Maitland, who informed him that it occurred in a large bed on the side of a deep gully near the head of the Manilla River, New South Wales, and that in it a small cave had been excavated, partly by the action of the weather, partly by kangaroos, wallaroos, and wallabies, who were continually licking it. On these animals the mineral evidently excited a purgative action. This action, Mr. Dixon considers,

must be mechanical, as the mineral contains no constituent soluble in water. It yielded him the following results by analysis:—

Water	10·64		10·64
Ferric Oxide	2·92	Soluble in acid	13·87
Alumina	9·76		
Lime	·67		
Magnesia	·52		
Alumina	6·36	Insoluble in acid	75·76
Lime	1·38		
Silica	68·02		
	100·27		100·27

Hardness 1.—Specific gravity of powder 2·1, of mass dry about 1. It is infusible before the blowpipe, but contracts greatly by heat; adheres slightly to the tongue, and is devoid of plasticity.

Professor Liversidge mentioned that specimens of a very similar mineral had been sent to him as meerschaum from the Richmond and Clarence Rivers.

SECTION C.—GEOLOGY AND PALÆONTOLOGY.

At the preliminary meeting of this Section, it was resolved to amalgamate it for the present with the Chemical Section.

SECTION D.—ZOOLOGY AND BOTANY, INCLUDING ENTOMOLOGY.

No meetings of this Section were held.

SECTION E.—MICROSCOPICAL SCIENCE.

PRELIMINARY MEETING—23 JUNE, 1876.

The first meeting of this Section was held on the 23rd June, 1876.

Professor Liversidge, as General Secretary, opened the proceedings by drawing attention to the circular summoning the meeting. The election of officers was then proceeded with, with the following results:—Alfred Roberts, M.R.C.S., Chairman. Committee: Mr. Wm. MacDonnell, Mr. H. Paterson, Dr. Milford, Dr. Belgrave. Secretary, Mr. G. D. Hirst.

It was resolved that the Council should be applied to for a specimen cabinet for the reception of microscopic slides.

It was decided that the future meetings of this Section should be held on the third Wednesday in each month.

WEDNESDAY, 19 JULY, 1876.

ALFRED ROBERTS, M.R.C.S., in the Chair.

After arrangements had been made as to the future conduct of business brought before the Section, the Chairman presented a collection of slides of diatoms, mounted and named by Dr. Smith of Edinburgh.

Mr. ROBERTS then exhibited a very convenient arrangement for mounting with despatch and freedom from air-bubbles objects in Canada balsam. It consists of a tin stand constructed to hold water, which is kept hot by a spirit lamp underneath, the balsam contained in a small glass tube being retained in a fluid state by the steam which is confined in an outer chamber. The top of the stand forms a table on which the slides are laid during the operation of mounting, and by which they are kept warm as long as is desired. Mr. Wm. MacDonnell exhibited a large microscope by Powell and Lealand, with a quantity of accessory apparatus. This instrument was lent for the occasion by Mr. Cathcart of Newtown. Mr. H. Paterson exhibited an injection of the dentinal pulp of a kitten. This slide possessed special interest, having been prepared by the late Professor Queckett. Mr. George Hirst, a slide showing the formation at a very early date of striated muscular fibre in the human embryo. Dr. Milford, some scolices of Eccinococcus from the human subject. Some German objectives, on the immersion principle, by Siebert, were also exhibited by Mr. MacDonnell. These lenses possess remarkable defining and penetrating power, and work through considerable thickness of covering glass.

WEDNESDAY, 16 AUGUST, 1876.

ALFRED ROBERTS, M.R.C.S., in the Chair.

There was a good attendance of members. The Secretary reported that, in response to the request of the Committee, the Council of the Society had sent to London for a substantial microscope stand and necessary addenda for the use of this and the other sections.

Mr. H. PATERSON presented a slide containing a section of the dentinal tubes and enamel of the adult human tooth.

Mr. G. D. HIRST read a paper on the action of alkali on wool fibres.

Dr. MILFORD read a paper on the starch of the *Macrozamia spiralis.*

The following objects were exhibited :—By Mr. ALFRED ROBERTS, duodena of toad and black snake injected, and ova of frog; Mr. H. PATERSON, sections of teeth; Mr. TOOHEY, *Torula* or yeast plant; Mr. WM. MACDONNELL, scales of *Morpho menalaus.*

WEDNESDAY, 20 SEPTEMBER, 1876.

ALFRED ROBERTS, M.R.C.S., in the Chair.

The CHAIRMAN presented several well-mounted slides of foraminifera, mounted by Möller of Hamburgh.

Mr. W. MACDONNELL presented a series of twelve slides of foraminifera procured from soundings in different parts of the globe.

Mr. HUGH PATERSON presented a slide showing a case of exostosis of the human tooth, and accompanied his gift with some remarks on the nature of this disease.

Mr. G. D. HIRST presented a slide of a species of polyzoa common in Port Jackson; also a slide containing a section of schirrhus cancer mounted in glycerine.

Mr. E. WOODGATE presented a slide of crystals of salicine; also a section of pith of elder.

The CHAIRMAN presented a number of papers by Mr. Greville on new diatoms.

Mr. G. D. HIRST read a note on a species of chelifer found near Sydney, and common in dry wood and old lumber rooms, or in out-houses near scrub.

The CHAIRMAN exhibited specimens of the fangs of the death-adder and cobra, and explained their structure.

Mr. W. MACDONNELL exhibited a series of slides illustrative of human anatomy, and showing great skill in their preparation; Mr. H. PATERSON, sections of human bone; Dr. MILFORD, specimens of different types of cancer; Rev. GEO. MARTIN, a series of well-prepared slides in dammar varnish, sections of wood fibre mixed with coal from below a coal seam at Newcastle, foraminifera, also antennæ and palpi of tarantula.

Resolved:—That the subject for the next meeting should be diatoms in reference to their power as test objects.

WEDNESDAY, 18 OCTOBER, 1876.

ALFRED ROBERTS, M.R.C.S., in the Chair.

Resolved that the following proposal be submitted to the Committee of the Section:—That the Secretary be instructed to communicate with the *London Monthly Microscopical Journal*, with a report of the formation of the Section; and stating that, in the event of the proprietors being willing, monthly reports of the meetings would be forwarded to them for publication.

Mr. G. D. HIRST exhibited a rare and curious old publication, lent for the occasion, being a series of copper plates of microscropic objects, published by the celebrated Dr. Hooke 210 years ago, and entitled "*Micrographia*." He drew attention to the excellence of these plates, which are the more remarkable when there are taken into consideration the rude and inefficient optical instruments at the disposal of microscopists at that early date.

The CHAIRMAN made some remarks upon the work, and stated that much had been done of infinite value to science by earnest observers using what would appear to us with our modern advantages totally inadequate instruments; and he wished, while speaking on the subject, to pay a tribute of respect to the memory of the late Mr. Wm. Sharp M'Leay, who, with only a simple dissecting miscroscope, rendered vast service to microscopic science by his researches, more particularly in those relating to the minute anatomy of insects.

Mr. WM. MACDONNELL exhibited a new hand magnifier by Browning, and called by him the Platyscopic lens. This is a triple achromatic combination, in which the spherical and chromatic aberrations were corrected by a central lens of dense glass. It is remarkable for its large and flat field and excellent definition.

A competitive trial of objectives of ⅛ in. focus took place, and a committee was appointed to report upon the merits of the glasses. The following makers were represented:—Messrs. Ross, Powell and Lealand, Smith and Beck, Crouch, Swift, Pillisher, and Gundlach. After careful examination, it was unanimously decided that Swift bore the palm for excellence of definition and resolving power, Ross and Powell and Lealand following very closely.

The Rev. GEO. MARTIN exhibited some very beautiful forms of discoidal diatoms, and some specimens of diatoms from Port Jackson were exhibited by the Chairman.

THURSDAY, 24 NOVEMBER, 1876.

ALFRED ROBERTS, M.R.C.S., in the Chair.

This meeting was postponed from the 15th inst.

A paper was read by Mr. J. U. C. COLYER on two species of insectivorous plants, *Drosera binata* and *Drosea spathulata*, indigenous to the Colony, and found in marshy ground near Sydney. The paper was accompanied by specimens of the plants in their natural state, and also by slides showing their microscopical structure.

Mr. G. D. HIRST made some remarks upon the paper read by Mr. Colyer, and exhibited some coloured drawings of the *Drosera binata* illustrative of the anatomy of the tentacles; these drawings he presented to the Section.

The CHAIRMAN stated that he hoped Mr. Colyer would make the paper delivered only the first of a series on the subject. Mr. Colyer undertook to prosecute the matter further and place the results before the Section.

The SECRETARY read a paper received by him from Mr. H. J. Brown, of Newcastle, on the milky juice of the climbing fig. The paper was accompanied by a specimen slide forming a good polariscopic object. He also, on behalf of Mr. Brown, presented to the Society's Cabinet several slides, being chiefly spiculæ of marine animals found on the coast near Newcastle.

THE MACROZAMIA SPIRALIS.

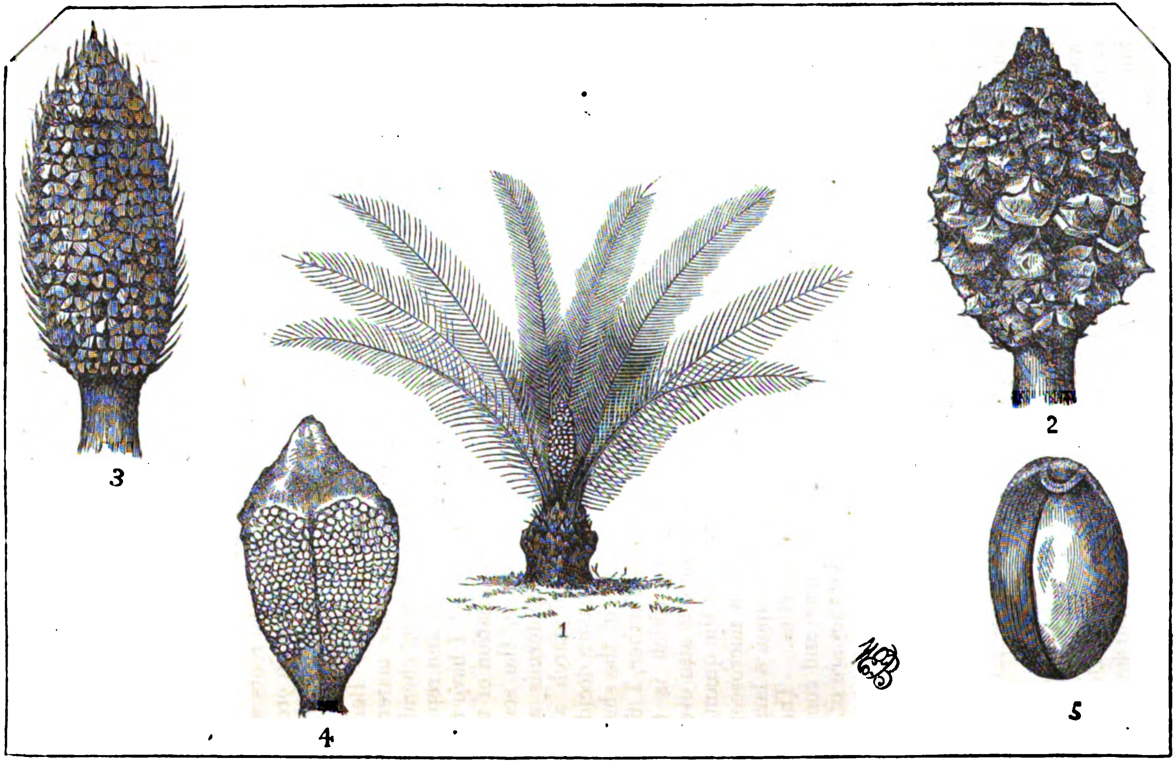
By F. Milford, M.D., M.R.C.S., &c.

[*Read before the Microscopical Section of the Royal Society of N.S.W.*, 6 *August*, 1876.]

In the first number of the second volume of the New South Wales *Medical Gazette* is a paper on the *Macrozamia spiralis*, from the pen of Dr. G. Bennett, F.L.S. F.G.S., &c., &c. It was called forth by the fact that a child was taken seriously ill after partaking of the uncooked and unprepared nuts. Mr. W. C. Brown, M.L.A., wrote to Dr. Bennett on the subject, who in consequence indited the paper referred to, from which I cull a portion of the following brief notice :—"The *Macrozamia*, of the order *Cycadaceæ* or *Cycads*, are trees or shrubs having the appearance of palms and in some particulars of ferns. The flowers are diœcious (the male and female flowers being on separate plants). Both the male and female flowers are borne in cones composed of woody scales with a truncated six-sided summit, and the male flowers are arranged in tesselated catkins, the scales peltate; fruit, two at the under side of each scale. The stem beneath the surface of the earth and at a slight elevation above is in shape conical, but when it attains a greater elevation, which in New South Wales it does to the height of six or eight feet, it becomes cylindrical. The cone is about the size of a man's head, and composed of drupes about the size of a chestnut. Abundant fossil remains show that the plant formerly composed a large portion of the foliage of the British Isles." The plant is abundant about Sydney, and numbers may be seen near Bondi at present. If any one should have the desire of viewing the plant in its native habitat, he may do so at the foot of the hill near Bondi on the Old South Head Road. He should turn to the right down a track that leads to Bondi beach, and there numerous plants may be seen occupying an area of about two acres on the bank of a watercourse about one hundred yards from the main road. The plants usually occupy a limited space in the way thus indicated, and are found in sandy or rocky soil. The fronds of the plant have a very elegant appearance, resembling palms, and are used in Catholic Churches on Palm Sunday and for other decorative purposes in New South Wales. I remember when a youth of thirteen or fourteen years old procuring some of the nuts and taking them home for the purpose of eating them. I had not been long in the Colony at that time and had a distinct recollection of the flavour of English chestnuts, which these nuts so much resemble, so that I anticipated a great treat in eating them. I had three; one I

ate myself uncooked, and two I gave to my French governess. The effect upon me I shall not readily forget; it was as if I were suffering from a severe attack of sea sickness, accompanied by diarrhœa and cramps in the abdomen. However, I was perfectly recovered next day; not so, however, with the French lady, who was of rather a bilious temperament, and partaking of more of the nut than I did, she was laid up in bed for the space of a week, but eventually recovered under medical treatment. Before the colonisation of this country, the aborigines made use of the nuts; and the starch procured from the nuts and the roots was one of the chief supplies of their farinaceous food; but in order to get rid of the deleterious qualities of the contents of the nut, they were exposed to a constant stream of water on a sheet of bark for some days, and afterwards thoroughly roasted. Being desirous of ascertaining the nature of the poisonous material contained in the nut and tuber, I requested Mr. Norrie, chemist, of William-street, some time ago to make an analysis, and report upon it. He wrote to me afterwards as follows:—"I have the pleasure now to give you some account of my examination of the nuts of the *Macrozamia spiralis*. In the first place, the seeds were perfectly dry. On removing the shell and epidermis and pulping the seed, I obtained a large quantity of starch and gluten; testing the soluble portion, it was found to have a decided acid re-action; lime-water throws down oxalic acid in the shape of oxalate of lime; continuing my investigations further, I find a potash salt and isolate binoxalate of potash, which is the poisonous substance contained in these nuts. There is also every appearance of an alkaloid crystallizing in prisms, but the quantity operated on was so small that I could only get a microscopic specimen, it therefore requires further examination upon a larger quantity of material to test its particular properties. These seeds contain also vegetable albumen, gum, and sugar; and consequently as an article of food, as used by the blacks, they are of no mean value; for it must be remembered that in the roasting of these nuts, the binoxalate of potash would be converted at a low red heat into carbonate, modifying or completely destroying the poisonous properties."

Mr. Henry Moss, of Shoalhaven, has been for some time past engaged in manufacturing an edible starch from the nuts and tuber of the *Macrozamia*. The means he uses are these: he has the shells broken away from the nuts, then placed in tubs of cold water, and pounded quite soft with a wooden rammer, then roughly strained to get all the debris away, than strained through fine cloth and the liquid allowed to stand for forty-eight hours in a long cask; spill holes are made in the cask, a few inches from the bottom, so that the water can be drawn off without disturbing the sediment. After draining and adding fresh water, the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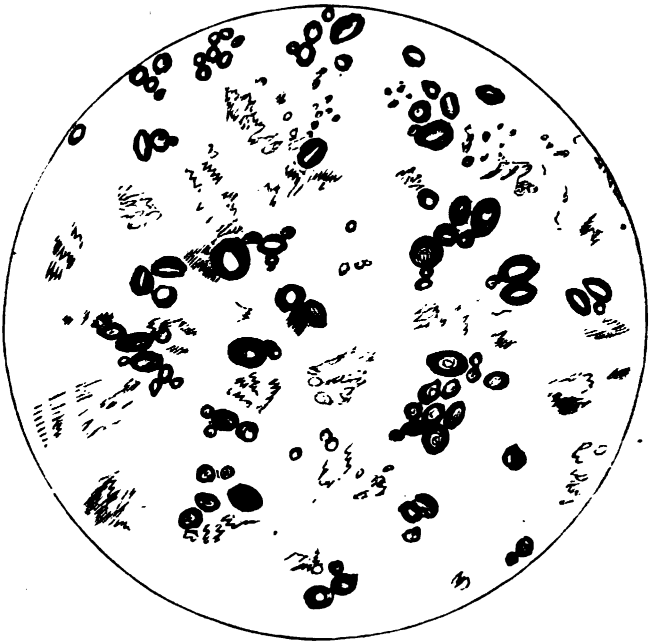

starch forms a cake at the bottom, the water is then all drawn off, the cake of starch cut out, and dried in the sun, and afterwards rolled. He calls the starch arrowroot, and says it is "as fine as any commercial arrowroot." He states that an infant child in the Shoalhaven district was reared upon it and nothing else. He sent me some pounds of it, and I gave samples to many of my friends. I also had some prepared for myself for breakfast, in spite of my previous unpleasant experience of it, and I was much pleased with its flavour, and as an article of diet I can recommend it to those who prefer light and nutritious food to beefsteaks and porter. I consider Mr. Henry Moss deserves the thanks of the community for thus inaugurating a valuable article of food, and I consider that they should take a substantial form, thus giving a material guarantee of our appreciation of his efforts to benefit mankind. It has been said "that the man who makes two blades of grass grow where one only grew before is a benefactor to his species"; how much more is he who gives us an abundant supply of a perfectly new, nutritious, and palatable article of food. I have brought with me this evening a specimen of the starch granules of the *Macrozamia* mounted dry. The smaller grains are chiefly round, rarely oval, the larger are perfect ovoids, resembling so many small birds' eggs. They differ from the other varieties of starch, as depicted in the second part of the second volume of the third edition of Pereira's "Materia Medica," and are "*sui generis.*" I have also brought a specimen frond of the plant for your inspection.

REFERENCES TO ENGRAVINGS:—

No. 1. *Macrozamia* spiralis.
No. 2. Female cone.
No. 3. Male cone.
No. 4. Under view of male cone bearing anthers (nat. size).
No. 5. Seed (nat. size).
No. 6. Granules of *Macrozamia* starch, magnified 390 diameters.

TRANSVERSE SECTION OF FANG OF HUMAN TOOTH, SHOWING CASE OF EXOSTOSIS.

BY MR. HUGH PATERSON.

[*Read before the Microscopical Section of the Royal Society of N. S. W., 20 September*, 1876.]

THE fangs of the teeth are, under ordinary circumstances, covered on the external surface with a thin layer of cementum, but when, whether from caries or any other cause, irritation of the dental periosteum takes place, it gives rise—in some constitutions—to the morbid growth termed exostosis, if the word may be allowed to pass muster, as strictly speaking it is the cementum, a modified form of bone, which is here enlarged.

"Mr. Jones, who has made careful microscopical examinations of this substance, describes it as being similar to osseous tissue, its structure being composed of minute granules closely united, the individual granules being about the $\frac{1}{10,000}$ of an inch in diameter. Scattered through the so-formed tissue are cells from which numerous tortuous tubes proceed, the tubes themselves freely anastomosing with each other and with those sent from neighbouring cells; by this arrangement a network of cells and tubes, permeable by fluids, is carried throughout the whole mass. When the cement exists in any quantity it is traversed by canals for blood-vessels."

The interest attached to this disease is mainly due to the derangement it may cause to the nervous system. In my younger days, when in London, I had occasion to remove some eighteen teeth and stumps, all more or less affected by exostosis, before permanent relief was afforded.

Another case which may be of interest to this Section, on account of the name of the sufferer, was that of the late Rev. Wm. Quekett, brother of the late Professor John Quekett, whose labours as a pioneer in microscopical research are well known and respected. The offending tooth in this case was an upper molar; it caused great and long continued suffering, and the exostosis was of a very extensive nature.

This tooth is in the Hunterian Museum of the Royal College of Surgeons of London. I remember that at the time it impressed me as bearing some distant resemblance to a rustic garden stool, so nodulated and distorted were the fangs by the hypertrophy of the cementum.

NOTES ON TWO SPECIES OF INSECTIVOROUS PLANTS INDIGENOUS TO THIS COLONY.

BY J. U. C. COLYER.

[*Read before the Microscopical Section of the Royal Society of N.S.W.*, 24 *November*, 1876.]

ON August 28th, 1874, a most interesting address was delivered by Dr. Hooker at the British Association in Belfast, Ireland, on the subject of Insectivorous Plants, and more especially with reference to that known as *Dionæa muscipula* (Venus's Fly-trap). So great was the interest taken at the time on this subject of vegetable carnivora, that illustrations appeared in the *Graphic* of plants possessing this peculiar property, and grown in the Royal Botanic Gardens, Kew. Since then my attention has been directed towards certain plants indigenous to this country, belonging to the order of *Droseracæ* or "Sun-dews" and more particularly to the *Drosera spathulata*, and *Drosera binata*, specimens of which I now beg to place before this meeting.

They are both found in marshy or swampy ground near Sydney, and are attractive to the eye by the numerous sparkling minute drops of clear fluid, like dew, adhering to the long slender filaments by which the edge and upper surface of the leaves are surrounded.

On warm days this peculiarity seems to be greater, or in no way decreased, as might naturally be supposed, by the extreme heat of a mid-day sun.

This fluid is of a glutinous nature, forming an attraction to flies and other insects, all of which find certain death, when once they alight on either the mid-rib of the frond of *Drosera binata*, or are entangled in the viscous globules exuded by either plants on the outer ends of their filaments.

The order to which these plants belong have not only been considered insectivorous in their habits, but also carnivorous, and as many of you may be aware, have been subjected to minute and careful examination with various experiments, by such eminent men as Professor Darwin, Dr. Klein, Dr. Hooker, Dr. Burdon Sanderson, and others, all of whom concur in the one opinion, viz.: that they are beyond doubt vegetable carnivora.

The *Drosera spathulata*, so called from the resemblance of its leaves to the spathula used by chemists, has a remarkable starry appearance, and is of a dun-red colour, each leaf fringed round with numerous filaments or tentacles. I have never noticed the plant to exceed two (2) inches in diameter.

The flowers are racemed, or borne in bunches on a stem rising from the centre to a height of about five (5) inches, and are pure white.

The *Drosera binata* is a much larger plant, and of an entirely different appearance, though, like the former, the sides and upper surface of the leaves are armed with tentacles of considerable length, some extending half an inch, and the points of each bearing small pear-shaped knobs or glands, from which issue the clear viscid fluid.

It attains a height sometimes in favourable localities of twenty (20) inches; each stalk is of a rush-like character, and bearing two blade-leaves of almost an eighth of an inch in width—bifurated once always, and sometimes more. These not unfrequently attain a length of seven and a half (7½) inches from its junction with the stalk; the mid-rib of each being hollowed out on both sides, but more on the inner, giving the appearance of grooves. The apex of the blades is extremely fine, terminating in very long tentacles.

The flowers are similar in many respects to *Drosera spathulata* with the exception that the stalk issues immediately from the root and is of a chocolate colour, differing in that particular from the stalks of the leaves, which are green.

Seen under a microscope with a low power, the leaf presents a curious and most interesting appearance; the whole of the mid-rib often completely covered with the remains of insects caught, and apparently dissolved or digested, and upon examination these are found to be but the mere shells or cases of the former flies, all of which are found longitudinally placed on the mid-rib of the blade, and their natural hue changed to black. Even bush ants half an inch in length I have seen unable to extricate themselves from the tentacles, the marginal rows possessing the marvellous power of closing over their victims and gluing them firmly to the smaller and shorter glands rising from the centre of the blade.

When insects are thus entrapped, their struggles to become free excite the glands to such an extent that they immediately inflect on the irritating object, and the glutinous matter (which, by the way, has been proved to be albumen), heretofore possessing little or no acridity, now appears by the inflected action of the tentacles to have changed its nature and become most acrid, litmus paper being immediately tinged with it. Mr. Darwin states, in his work on "Insectivorous Plants" (page 86), referring to an experiment on the leaves of *Drosera rotundifolia* (a plant resembling *Drosera spathulata*) that "The secretion of many glands on thirty leaves, which had not in any way been excited, was tested with litmus paper; and the secretion of twenty-two of these leaves did not in the least affect the colour, whereas

that of eight caused an exceedingly feeble and sometimes doubtful tinge of red. Two other old leaves, however, which appeared to have been inflected several times, acted much more decidedly on the paper. Particles of clean glass were then placed on five of the leaves, cubes of albumen on six, and bits of raw meat on three, on none of which was the secretion at this time in the least acid. After an interval of twenty-four hours, when almost all the tentacles on these fourteen leaves had become more or less inflected, I again tested the secretion, selecting glands which had not as yet reached the centre or touched any object, and it was now plainly acid. The degree of acidity of the secretion varied somewhat on the glands of the same leaf."

The secretion so discharged has been examined by Dr. Darwin, in order to ascertain whether this acrid matter approaches to the gastric juice or digestive material found in the stomachs of animals, and the experiment showed that "the acid belongs to the acetic or fatty series" (see page of "Insectivorous Plants" 88.)

Professor Frankland observed of the fluid taken from the filaments of *Drosera rotundifolia* that "when acidified with sulphuric acid it emitted a powerful odour like that of pepsin."

By the kindness of Mr. Hirst, the Secretary of this Section of the Royal Society, I have been enabled to examine with his microscope the structure of these plants, more especially *Drosera binata.* On placing one of the tentacles of the latter under a low magnifying power its structure is fairly displayed. It consists of a straight, pale green hair, carrying at the end a balloon or pear-shaped gland, of a red or scarlet hue, in some cases more brilliant than others; but on increasing the power to 1,400 diameters, by a sixteenth inch immersion lens, the character of the gland is more clearly defined. We see that the spiral vesicle which traverses the centre of the pedicel increases in breadth as it approaches the gland, and divides into two branches, each branch of which, as it reaches the centre of the gland, doubling backwards and forwards on itself several times, the whole at first sight having the appearance of pistil of a poppy. The spiral vesicle passes from the gland down the pedicel to the mid-rib of the frond, and in *that* also, upon further investigation, can this spiral arrangement of cells be found.

The pedicel bearing the gland is apparently divided lengthwise into rows of elongated cells; those contiguous to the spiral formation being filled with a fluid containing granules of matter, frequently found in an aggregated condition, but having an ever-changeful irregular motion. This matter is frequently understood by the word "*protoplasm.*" In *Drosera rotundifolia,* Darwin states that in the course of a few minutes he has noticed these germs undergo many changes, and that they pass up and

down the walls of the cells through the fluid, uniting, separating, and reuniting, being never at rest, "presenting a wonderful scene of vital activity." Referring to *Drosera binata*, I would again remark that I have noticed this action is entirely confined to the cells next the spiral column or duct.

It has been surmised that the inflection of the tentacle is produced by the contraction of the cells, caused by the pressure of the irritating or exciting object, and consequent increased aggregation of the germs against the walls in the cells, sending its motor impulse down the tentacle to the base, at which part it seems to bend, but considerable difference of opinion has been expressed on this point. Mr. Darwin says:—"On the whole, the belief that the walls of certain cells contract, some of their contained fluid being at the same time forced outwards, perhaps accords best with the observed facts. If this view is rejected, the next most probable one is that the fluid contents of the cells shrink, owing to a change in their molecular state, with the consequent closing in of the walls. Anyhow, the movement can hardly be attributed to the elasticity of the walls, together with a previous state of tension."

No comparison can be made with the action of the "Sensitive Plant" (*Mimosa pudica*) in the closing of its leaflets when irritated, this being merely mechanical and assumed nightly by the plant as if in repose, whereas the secretion from the inflected tentacles continues without interruption until the whole of the juices of the exciting object have been absorbed. The effect of a shower of rain on the Sensitive Plant would immediately close the leaflets, whereas heavy rain or water falling in large drops frôm a considerable height do not in the least move the tentacles of the *Drosera*.

On observing some of the inflected tentacles after the capture of an insect, one cannot but be struck with the change effected in them, compared with those taken from the plant in its normal condition. The red colouring matter, heretofore confined to the gland, has now descended the green pedicel as far as the base, and apparently granulated into cakes, also on the outside of the gland towards the head may be seen numerous black nuclei, possibly the mouths of channels leading into the spiriferous cells of the same, nevertheless the protoplasm in the pedicel is still moving, though slowly, and slightly agglomerated. This would in a measure show a tendency of the fluid to flow towards the mid-rib of the frond caused by the action of absorption.

Placing small pieces of raw meat on a healthy full-grown plant, I found that within three hours the marginal tentacles were inflected, and in twenty-four hours the meat was completely enveloped in their folds—the leaves as well as the tentacles of *Drosera spathulata* being entirely curled over it. On separating

some of the tentacles from this plant they presented the same granulated appearance.

The effect of the application of heat by boiling is to produce coagulation of the albumen, and render the whole of the glands opaque, and of a brilliant white porcelain appearance,—the tentacles are immediately bowed back, and the whole of the frond rendered flaccid; but on submitting another portion of the frond to either the fumes of strong ammonia, or immersion in a very slight solution of liquid ammonia and water, the result obtained was the instant inversion of the marginal tentacles, the total disappearance of the red colour from the whole of the glands, and the matter in them agglomerated into black nuclei. But upon boiling a section of the frond in a solution of caustic potash and distilled water, to obtain a better view of the structure of the spiral cells, I discovered that the back of the mid-rib of the frond was studded with a number of stomata or breathing-vessels, which heretofore have apparently not been observed.

On repeating the same experiment on some of the inflected tentacles which had enveloped a common house-fly, the black spots which before were seen arranged around the head of the gland now vanished, proving in a negative manner that they consisted of nitrogenous matter absorbed into the orifices by the plant.

One other remarkable feature deserving especial notice are a number of dorsal tentacles, having no power of movement, yet capable of absorbing nutritive juices.

I have noted with some curiosity the occasional presence of a small insect or fly on the fronds of the *Drosera binata*, from about a quarter to half an inch in length, smooth and glossy, of a red colour, with black and white spots on the backs of the bodies, and long clean legs, devoid of hairs. It possesses the remarkable power of walking all over the fronds without in any way being impeded, or entrapped (as all other insects are) by the treacherous drops of viscid fluid exuded from and adhering to the glands. Most plants have their insect enemies, such as worms, &c., which draw their nutriment from the leaves which they devour; but strange to say, this particular fly does not seem to destroy the blades of the *D. binata* in the least, and only lives on the dead insects captured by the closing of the tentacles—also in one instance when fragments of raw meat were placed on the blades, the fly seemed to be attracted towards them.

There are many other points too numerous to mention in a paper of this length connected with these truly wonderful plants, and which would amply reward careful study. Several eminent authorities—Dr. Darwin especially—have given them much attention, and have written apparently exhaustively on the subject, but a careful observer will note much that has been left

unexplained, and many phenomena connected with their structure and habits, as yet untouched upon. There is a large field here that would amply repay a little perseverance, and even the few facts already observed and which I have endeavoured to put before you to-night, cannot but strike with wonder when viewed for the first time.

That the animal and vegetable kingdoms are in many respects closely allied none I think will be disposed to deny. Vegetable food is we know the means of subsistence to the bulk of animal life on the globe, but here we have an example actually of the reverse; for it has been proved that if these plants be deprived of the means of obtaining sustenance through the insects caught by them, as for example by enclosing them in a glass shade, they quickly become sickly and die, their roots not being formed for extracting nitrogenous or organic matter from the ground.

SECTION F.—GEOGRAPHY AND ETHNOLOGY.

At the preliminary meeting of this Section the following Committee was appointed:—

CHAIRMAN.—Mr. E. Du Faur, F.R.G.S.

COMMITTEE.—J. Manning, C. L. Sahl, A. S. Webster, The Hon. L. Fane De Salis, M.L.C.

HON. SECRETARY.—Wm. Forde.

Owing to the absence of some of the Committee from Sydney, it was not thought advisable to call the Section together until the September meeting, at which arrangements were made for the preparation of lists from the Public Libraries of this and the neighbouring Colonies, and from other sources, of all works bearing on Exploration in Australasia and the Islands of the Pacific, also for collating all information published on the Aborigines.

These matters are proceeding.

Tracings of Ice Charts showing the track of ships running down easting have been promised to this Section from the original belonging to Commodore Hoskins, R.N.

Commander Hoskins, R.N., of H.M.S. "Pearl," and Lieutenant Penn, of H.M.S. "Sappho," have kindly promised charts showing the recent alterations in surveys, and also discoveries made by the Admiralty in the Pacific.

The Free Librarian of Tasmania has forwarded a list of works on Exploration and the Aborigines. The Librarian Melbourne, and the Secretary of the South Australian Institute, have promised similar contributions.

The meetings of the Section have been so sparsely attended by members hitherto that no steps have been taken beyond making the preliminary arrangements above referred to.

E. Du FAUR,
Chairman.

WM. FORDE,
Hon. Secretary, Section F.

SECTION G.—LITERATURE AND FINE ARTS, INCLUDING ARCHITECTURE.

There have been six meetings of this Section, at three of which quorums have not been formed.

PRELIMINARY MEETING, TUESDAY, 27 JUNE, 1876.

Fourteen members joined, and the following elected office-bearers:—

CHAIRMAN.—E. L. Montefiore.
HON. SEC.—H. A. Lenehan.
COMMITTEE.—E. Du Faur, L. F. De Salis, G. Morell, W. G. Murray.

Business meetings arranged for fourth Monday of each month during session, and that the subject for first business meeting should be "Processes of Photographic Reproduction."

MONDAY, 24 JULY, 1876.

Mr. E. L. MONTEFIORE in the Chair.

Several members were present. A considerable number of examples of the various photographic reproductions were exhibited by members of the Section, also some of the pellicle patented by Mr. Kennett, of London, for his dry plate process. Mr. Russell submitted, for the information of the members, the cost of obtaining the use of Woodbury's patent, obtained by him from that gentleman during his recent visit to Europe. The plates exhibited printed by the process obtained from Mr. Woodbury himself were exceedingly beautiful. This process was considered to give not only much greater detail in the pictures, but greater rapidity in reproduction than other processes. After a lengthened discussion as to the various processes, it was resolved,—"That a letter be prepared, and submitted for the approval and signatures of the members, at the next general meeting of the Society, asking the Government to procure, for the use of the Government Printing Office, the process invented and patented by Mr. Woodbury, by which photographs taken direct from natural objects could be printed with all the truth-

fulness and detail of an ordinary silver print." In illustrating works of the natural history of the Colony, its buildings, public works, &c., it was considered that the process would be very valuable, and might very soon be made reproductive. It was resolved,—"That Count de Zaba be invited to attend the next meeting of the Section, to be held on the 28th proximo, for the purpose of explaining to the members his method for facilitating the study of universal history and literature."

The letter to the Government was signed by twenty-one members at general meeting.

MONDAY, 28 AUGUST, 1876.

COUNT DE ZABA was present by invitation, and in a conversational way gave a description of his method of historical teaching.

MONDAY, 25 SEPTEMBER, 1876.

No quorum.

MONDAY, 23 OCTOBER, 1876.

No quorum.

MONDAY, 27 NOVEMBER, 1876.

The last meeting of the session. Mr. E. L. MONTEFIORE read a very interesting paper on Etching and Etchers, illustrated by etchings by Rembrandt and others.

ETCHING AND ETCHERS.

BY E. L. MONTEFIORE.

[*Read before the Literature and Fine Art Section of the Royal Society of N.S.W.*, 27 *November*, 1876.]

He commenced by alluding to the common error of styling pen and ink drawings etchings, explaining that an etching was a drawing produced on a metal plate, by means of lines or strokes bitten in or corroded by the action of acid, from which impressions were afterwards taken through the medium of a printing-press—the artist's ideas being thus capable of reproduction; and that whilst it required a certain amount of skill in the use of pen or pencil to produce a good etching, a person might produce any charming pen and ink drawings although utterly ignorant of the art of etching. Mr. Montefiore then proceeded to show the difference between etching and engraving, the latter being more of a mechanical process, the effect being produced by a series of regular lines and dots, executed on metal with the "burin" without the aid of acid, and necessarily not possessing the freedom of the etching, in the execution of which the artist allows his needle to wander freely over the plate, as though he were drawing with pen or pencil, leaving it to the acid to give the necessary gradations of light and shade. Quoting from Gilbert Hammerton, himself an experienced etcher, he remarked that the central idea of etching was the free expression of purely artistic thought, and that of all the arts known it was the best fitted for that especial purpose. The ideal of an etching, said that writer, is that it should be free and spontaneous. When a plate has been laboriously corrected it always showed signs of fatigue, and so lost in freshness what it might have gained in delicacy and force. A certain kind of self-reliance, almost approaching a conviction of his own personal value, was necessary to an aquafortist. The needful elements of success in direct work of any kind was absolute sincerity and simplicity. Good etching, like good manners, did not hesitate about what is to be said or done, and though highly sensitive, was not painfully self-conscious. Above all, it casts away affectation, the vice of the inferior arts. Etching does not condescend, and therefore really need not be at the trouble to polish its phrases and explain. The truth of these remarks he considered abundantly exemplified in the works of Rembrandt, the great representative master of the art of etching.

Mr. Montefiore then proceeded to describe the various processes used by the etcher—viz., pure etching, dry point, aqua-tint, and soft ground etching. That these processes might be more clearly understood by the members present, he exhibited the various tools used in the different processes, and explained their uses, showing the plates in different states of progress. He also gave a lengthened and interesting account of the method of preparing the copper plates used in etching. As showing the necessity of reversing the drawing where accuracy was required, he instanced a curious error in an etching of the Life School of the Royal Academy, by Cope, the Royal Academician, in which the whole of the students are seen drawing with their left hands, whilst the model is drawing a sword from his right side.

Mr. Montefiore proceeded to observe that etching was believed to have been invented about forty years later than engraving, and was commonly practised in Germany in 1512; but that the great master of etching, whose name would always be associated with the art, was Rembrandt, who flourished in the early part of the 17th century. He then expatiated at some length on Rembrandt's marvellous skill as an etcher, the great apparent negligence of his etchings, their remarkable boldness and freedom, and wonderful distribution of light and shade. He stated that essays had been written on them in France, Holland, Germany, and England, and that Adam Bartsch, himself an engraver, keeper of the print room in the Vienna Museum, writing of him in 1797, said—"However great may be the reputation Rembrandt has acquired by his paintings, he is no less celebrated by his etchings, which have at all times excited the admiration of connoisseurs; a vagabond liberty, a picturesque disorder, an easy touch, the rarest perception of chiaroscuro, and the talent of expressing the character of the different ages and subjects he was treating, by touches thrown in as it were by chance. Such are some of the elements, and there are many others, which constitute the merit of Rembrandt as an engraver, which give such an inexpressible charm to his prints." Rembrandt, it was said, would never etch in any person's presence, so that many of his processes are unknown. As showing Rembrandt's wonderful rapidity, Mr. Montefiore related the following anecdote:—That being at table with his great friend and patron Burgomaster Six, the mustard-pot was asked for, and not being on the table, the servant was sent to fetch it. Rembrandt, knowing the tardiness of the domestic, laid a wager with his friend that he would commence and finish an etching before he returned, a feat he actually accomplished, the plate being known as "Six's Bridge, or the Mustard Pot." Remarking on the large sums given for Rembrandt's etchings, Mr. Montefiore stated that an impression of his portrait of the Burgomaster alluded to, which was generally

considered one of the most finished and perfect of Rembrandt's etchings, was sold in London in June last for £270, one of his celebrated portraits of Von Tolling for £500, and one of Ephraim Bonus, the Jewish physician, for £160. At this sale about 200 of his etchings realized £4,293. "Christ healing the Sick," better known as the 100-guilder piece, from the fact that Rembrandt would never sell an impression under 100 guilders (about eight guineas), was considered as Rembrandt's masterpiece. At a sale in London, in 1867, of Sir C. Price's collection, a copy of this in the first state of the plate realized the enormous sum of £1,180. The British Museum was supposed to contain one of the finest collections of Rembrandt's etchings. Mr. Montefiore then alluded to other celebrated painters of the 17th century who were skilful etchers, enumerating amongst others, Claud, Annibal Carraci, Rubens, Van Dyck, Ostade, Teniers, Salvator Rosa, Berghem, Paul Potter, &c.; he also dwelt on the works of Callot and Della Bella, two very prolific etchers who flourished during the same period.

Mr. Montefiore remarked that the art of etching had not been much practised or appreciated in England, although England had produced some very good etchers. Some years back a few artists had formed themselves into an Etching Club, and had published some of their etchings from time to time, which had been much sought after. Amongst English etchers might be mentioned—Turner, who, however, merely employed the needle for outline, filling in with mezzotint; Landseer in his early days had published a series of etchings; Wikie, David Roberts, Cope, Ansdell, Hunt, Millais, Creswick, Redgrave, &c., also etched. At the present day he considered that there was no English etcher equal to Seymour Haden, of wicker coffin celebrity, an amateur, and surgeon by profession. There was a boldness and free handling about his work not approached by any other etcher of the English school, and indeed there were few contemporary etchers equal to him elsewhere. Mr. Montefiore submitted for the inspection of the members a very fine example of Haden's, called the "Breaking-up of the Old Agamemnon" to which, at the time of its publication, the *Times* devoted a column and a half. He stated that there had been a great revival of the art of etching in France of late years, owing in great measure to the exertions of the well-known and enterprising publisher, Monsieur Cadart, who had made the printing and publication of etchings a speciality—his prints were, as a rule, much superior to those produced in England. Having already alluded to some of the old masters of the French school of etchers, such as Claude, Callot, &c., he would not occupy their time further by dwelling at length on the modern school, but would in conclusion, merely allude to one who might with justice be considered at its head,

viz., Maxime Lalanne, of whom it had been said that whilst there were etchers of greater power and more striking originality, there was never one equal to him in a certain delicate elegance from the earliest times till now. Maxime Lalanne was the first artist who ever received knighthood for his skill as an etcher, that honor having been conferred on him by the King of Portugal, himself an etcher. Mr. Montefiore illustrated his paper by a very interesting collection of etchings by ancient and modern artists, including works by Rembrandt, Berghem, Paul Potter, Hollar, Callot, Della Bella, Landseer, Lalanne, Haden, Millais, Jaquemart, Appian, Otto Weber, &c.

An interesting discussion then followed on the merits of the various processes: and before the meeting dispersed, a very cordial vote of thanks was accorded to Mr. Montefiore for his very interesting paper, with the request that he would allow it to be published.

The Chairman stated that, at a future meeting, he hoped, through the kindness of Messrs. J. Fairfax and Sons, that the members of the section would have an opportunity afforded them of seeing specimens of the process of electrotyping which was now largely used in printing.

SECTION H.—MEDICAL SCIENCE.

Dec. 2, 1876.

To the Honorary Secretaries of the Royal Society of New South Wales.

GENTLEMEN,

In pursuance of By-law No. XXX, we have the honor to forward a report of the proceedings of the Medical Section during the past session. The first meeting of the Section took place on June 28th. Alfred Roberts, Esq., was elected Chairman, and Drs. Cox, Cosby, Morgan, and Milford, and G. A. Wright, Esq., were elected Members of Committee. Dr. P. Sydney Jones was elected Honorary Secretary. At a subsequent meeting Dr. MacLaurin was associated with Dr. Jones in the Secretaryship. The monthly meetings have been fairly attended; pathological and other specimens have been exhibited, and interesting papers have been read. Rules for the guidance of the members of the Section have been drawn up, printed, and adopted. Donations have been made by Drs. Cox, Schuette, Ward, and Sydney Jones.

ALFRED ROBERTS, Chairman.

P. SYDNEY JONES, } Honorary
H. W. MACLAURIN, M.D., } Secretaries.

SECTION I.—SANITARY SCIENCE.

Report of the Social and Sanitary Science Section of the Royal Society for the session of 1876.

To the President of the Royal Society.

Sir,

I have the honor to submit the following report:—

The Social Science and Statistics Section held a preliminary meeting on the 29th June, when it was unanimously resolved that a proposition be submitted to the Council that Section H. Sanitary Science be joined to Section I, Social Science and Statistics. The proposal having been agreed to, the Section has since that date met as the Social and Sanitary Section.

At its first meeting, held on the 10th July, Mr. Roberts, M.R.C.S., was chosen as Chairman; Dr. Morgan, and Messrs. Bedford, M.R.C.S., Voss, and Tarleton were elected a Committee; and Mr. Harrie Wood was appointed Honorary Secretary.

The Section then decided that its ordinary meetings be held on the second Tuesday in each month.

Steps were taken to procure all the papers, etc., published by the Sydney and Suburban Sewage and Health Board, by the Victorian Central Board of Health, and by the English Board of Health, but the publications of the last-named Board have not yet been received.

At the meeting held on the 8th August, Dr. Belgrave called attention to the Vital Statistics published by the Registrar General, and pointed out certain defects therein. After careful consideration, it was generally admitted that in many cases the cause of death as stated rendered the statistics of comparatively small value as a basis for sanitary legislation. The defects appeared to be mainly due to want of care or want of skill on the part of the persons by whom certificates of death are granted; and in order to ascertain the facts a series of questions were submitted to the Honorable the Colonial Secretary. These questions elicited the following replies:—1. That the primary cause of death is given in all cases where specified in the certificate. 2. That the certificate of death is required principally for the purpose of statistics upon which sanitary legislation may be based. 3. That the Nosological table used here is the same as that used by the Registrar General of England. 4. That the statistics include deaths certified by persons other than legally qualified medical practitioners, but in what proportion is not at present known. These replies having been discussed, it was resolved that the papers be referred to the Medical Section, with a request that the members will consider the matter and favour this Section with the result of their deliberations.

On the 12th September Dr. BELGRAVE read a paper on "Preventable Disease and Sanitary Organization." The consideration of this paper engaged the attention of the Section at an ordinary and three special meetings. The subject was divided under three heads, and dealt with as follows:—1. That the poisons of cholera and typhoid fever are communicable by filtered water, and that there is danger of the Botany water supply becoming contaminated by organic poison. 2. That an efficient system of registration of infectious and contagious diseases, with a view to arresting their further development, would be beneficial to the community. 3. That the decomposition of filth can give rise to specific fevers. 4. That venereal disease is prejudicial to public health, and is more or less reducible under the combined influence of education and legislation. 5. That a State sanitary organization is urgently required in New South Wales. It was then resolved that the Royal Society be invited by this Section to wait upon the Government by deputation, and urge it to introduce during the next Session an efficient General Public Health Act and to appoint a Central Board with ample powers to see its provisions enforced.

On the 26th September Dr. BELGRAVE drew attention to the statistics of the mortality in the principal cities of Continental Europe recently published in the Journal of the British Medical Association, from which Sydney, in spite of its almost unrivalled natural hygienic advantages, is shown to be at present one of the most unhealthy cities in Christendom.

On the 10th October Mr. ROBERTS, M.R.C.S., laid on the table a memorandum which he had prepared at the request of the Colonial Secretary upon hygiene, especially in its bearings upon epidemics. Mr. Roberts also read some remarks on the measures adopted by him under the Government to prevent the spread of erysipelas. A communication was received from M. Jules Joubert forwarding a photograph of an apparatus for cleaning water-pipes, and asking the Section to move the Royal Society to offer a prize for the best display of exhibits in the Sanitary Department of the Agricultural Society's next Exhibition. The Section at a subsequent meeting adopted the following resolution:—That, in the opinion of the Social and Sanitary Science Section, the Royal Society might with advantage to the community co-operate *with* the Committee of the Agricultural Society in promoting the exhibition of all articles tending to advance sanitary science and improve sanitary appliances.

Dr. BELGRAVE called attention to the prevalence of small-pox in San Francisco, and the danger of the disease being brought to this Colony by means of the mail steamers from that port. It was generally admitted that the danger is great, and that precautionary measures should as far as practicable be taken,

and that the strongest reason for vaccination exists. At the same meeting a Committee was appointed to collect and prepare for publication and distribution useful information on domestic sanitation suited to general use.

On the 14th November, a paper by Miss CHASE, containing a few practical remarks upon the ventilation and management of emigrant ships, communicated by Mr. Roberts, was read. At the same meeting, Dr. SPENCER read a paper upon "A scheme for supplying Sydney with water from the Erskine Valley." Considerable interest in the subject was evinced by the members, some twenty-five of whom were present; and it is to be regretted that, owing to the lateness of the hour when the reading of the paper was concluded, it was impossible to devote much time to its discussion. The importance of the subject, however, and the substantial value of information contained in Dr. Spencer's paper, recommend it for publication in the Society's Transactions. The short paper by Miss Chase is of an essentially practical character; and I would suggest that it might with advantage be forwarded to the Government, with a recommendation to the effect that it should be transmitted to the Agent General of the Colony for his consideration.

In conclusion, I would recommend that the Committee appointed to collect and prepare for publication information on domestic sanitation be permitted to sit during the Society's recess.

I have the honor to be,

Sir,

Your most obedient servant,

ALFRED ROBERTS,

Chairman.

APPENDIX.

ABSTRACT OF THE METEOROLOGICAL OBSERVATIONS TAKEN AT THE SYDNEY OBSERVATORY.

LATITUDE 33° 51′ 41″; LONGITUDE 10h 4m 46s; MAGNETIC VARIATION 9° 32′ 45″ East.

JANUARY, 1876.—GENERAL ABSTRACT.

Barometer ... At 32° Faht.	Highest Reading	30·093 inches on the 27th, at 4 a.m.
	Lowest Reading	29·278 „ on the 5th, at 2 p.m.
	Mean Height	29·713

(Being 0·058 inch less than that in the same month on an average of the preceding 17 years.)

Wind ...	Greatest pressure... ...	11·0 lbs. on the 20th
	Mean Pressure	0·8 lb.
	Number of Days Calm ...	0
	Prevailing Direction ...	E.N.E.

(Prevailing direction during the same month for the preceding 17 years, N.E.)

Temperature	Highest in the Shade ...	90·8	On the 19th.
	Lowest in the Shade ...	57·7	On the 6th.
	Greatest Range	20·2	On the 8th.
	Highest in the Sun ...	131·6	On the 19th.
	Highest in Black Box with Glass Top	195·2	On the 19th.
	Lowest on the Grass ...	50·0	On the 6th.
	Mean Diurnal Range ...	12·7	
	Mean in the Shade ...	72·6	

(Being 1·5 greater than that of the same month on an average of the preceding 17 years.)

Humidity ...	Greatest Amount... ...	97·0	On the 20th.
	Least	50·0	On the 19th.
	Mean	74·0	

(Being 1·2 greater than that of the same month on an average of the preceding 17 years.)

Rain... ...	Number of Days	16 rain and 2 dew.	
	Greatest Fall	0·468 inch.	On the 5th.
	Total Fall...	0·967 „	65 ft. above ground.
		1·421 „	15 in. above ground.

(Being 2·627 inches less than than of the same month on an average of the preceding 17 years.)

Evaporation	Total Amount	9·392 inches.
Ozone ...	Mean Amount	5·7

(Being 1·2 greater than that in the same month on an average of the preceding 16 years.)

Electricity...	Number of Days Lightning	6
Cloudy Sky...	Mean Amount	6·4
	Number of Clear Days ...	0
Meteors ...	Number Observed ...	4

Remarks.

The mean barometer is slightly below, and the mean temperature 1·5 above the average of this month for the past 17 years. Rain has been frequent but very light at Sydney; and generally over the Colony the dry weather has continued, doing great damage to pastoral and agricultural interests. At a few of the stations, on the high lands and on the coast, there has been sufficient rain. Thunderstorms have been frequent, and hail fell on 2nd, 5th, 16th, and 20th. Hot winds are recorded on the 1st and 2nd at Narrabri, on the 8th at Moss Vale, and on the 12th at Wentworth.

GOVERNMENT OBSERVATORY, SYDNEY.

LATITUDE 33° 51′ 41″; LONGITUDE 10h 4m 46s; MAGNETIC VARIATION 9° 32′ 45″ East.

FEBRUARY, 1876.—GENERAL ABSTRACT.

Barometer ... At 32° Faht.	Highest Reading	30·052 inches	on the 28th, at 9 p.m.
	Lowest Reading	29·209 „	on the 10th, at 12 noon.
	Mean Height	29·782	

(Being 0·012 inch less than that in the same month on an average of the preceding 17 years.)

Wind ...	Greatest Pressure... ...	12·5 lbs.	on the 26th.
	Mean Pressure	1·0 lb.	
	Number of Days Calm ...	0	
	Prevailing Direction ...	S.	

(Prevailing direction during the same month for the preceding 17 years S.)

Temperature	Highest in the Shade ...	96·9	On the 25th.
	Lowest in the Shade ...	57·5	On the 24th.
	Greatest Range	34·0	On the 25th.
	Highest in the Sun ...	132·0	On the 25th.
	Highest in Black Box with Glass Top ...	136·8	On the 26th.
	Lowest on the Grass ...	45·7	On the 24th.
	Mean Diurnal Range ...	12·9	
	Mean in the Shade ...	71·0	

(Being 0·4 greater than that of the same month on an average of the preceding 17 years.)

Humidity ...	Greatest Amount... ...	99·0	On the 10th.
	Least	45·0	On the 25th.
	Mean	71·1	

(Being 4·0 less than that of the same month on an average of the preceding 17 years.)

Rain... ...	Number of Days	14 rain and 1 dew.	
	Greatest Fall	0·523 inch.	On the 28th.
	Total Fall	0·902 inch.	65 ft. above ground.
		1·360 inch.	15 in. above ground.

(Being 5·468 inches less than that of the same month on an average of the preceding 17 years.)

Evaporation	Total Amount	7·696 inches.	
Ozone ...	Mean Amount	7·1	

(Being 2·5 greater than that in the same month on an average of the preceding 16 years.)

Electricity...	Number of Days Lightning	7
Cloudy Sky...	Mean Amount	6·6
	Number of Clear Days ...	1
Meteors ...	Number Observed ...	2

Remarks.

This month has been exceedingly dry and hot; from nearly all parts of the Colony come accounts of severe drought, and heavy losses in consequence; in one case a whole flock of 10,000 sheep died while going to water, and the number of dead sheep and cattle in the back country is immense. In Sydney the rainfall for the month is $5\frac{1}{2}$ inches less than the average, and it is less than that for any February since 1854. The temperature has been above and the humidity 4·0 below the average, so that evaporation has been very great, and in many places water, even for household purposes, has been obtained with difficulty. In the suburbs not supplied by water pipes the price of water has been from 5s. to 10s. per cask. On the 16th a very severe cyclone occurred at Bowen, in Queensland; it destroyed everything in its direct track, and carried some wooden houses bodily a considerable distance; the storm was accompanied by thunder and balls of fire, one of which made a round hole into one of the houses. On the 23rd a water spout was seen at sea off Cape St. George. On the 26th and 27th tides in Sydney harbour were unsteady, and at 2·30 p.m. of the 27th the water in harbour suddenly rose 5 inches in twelve minutes. From 5 p.m. on 26th to morning of 27th the barometer was very unsteady at Sydney, and from 2 to 2·35 p.m. of 27th it rose rapidly, and at the end of that time fell 0·050 in 5 minutes, the fall being almost coincident with the rise in the water. At New Zealand a heavy earthquake shock occurred at 3 a.m., and another at 9 a.m., on the 26th; smaller shocks were felt for some days.

GOVERNMENT OBSERVATORY, SYDNEY.

LATITUDE 33° 51′ 41″; LONGITUDE 10h 4m 46s; MAGNETIC VARIATION 9° 32′ 45″ East.

MARCH, 1876.—GENERAL ABSTRACT.

Barometer ... At 32° Faht.	Highest Reading	30·068 inches on the 22nd, at 10 p.m.	
	Lowest Reading	29·448 „ on the 25th, at 3·45 a.m.	
	Mean Height	29·848	

(Being 0·047 inch less than that in the same month on an average of the preceding 17 years.)

Wind ...	Greatest Pressure... ...	13·5 lbs. on the 31st.	
	Mean Pressure	0·7 lb.	
	Number of Days Calm ...	0	
	Prevailing Direction ...	E.	

(Prevailing direction during the same month for the preceding 17 years N.E.)

Temperature	Highest in the Shade ...	89·6	On the 26th.
	Lowest in the Shade ...	54·6	On the 31st.
	Greatest Range	24·3	On the 24th.
	Highest in the Sun ...	127·0	On the 25th.
	Highest in Black Box with Glass Top ...	187·7	On the 16th.
	Lowest on the Grass ...	43·6	On the 31st.
	Mean Diurnal Range ...	12·5	
	Mean in the Shade ...	71·9	

(Being 2·9 greater than that of the same month on an average of the preceding 17 years.)

Humidity ...	Greatest Amount... ...	94·0	On the 13th.
	Least	30·0	On the 30th.
	Mean	71·1	

(Being 5·5 less than that of the same month on an average of the preceding 17 years.)

Rain... ...	Number of Days	9 rain and 2 dew.	
	Greatest Fall	0·294 inch.	On the 17th.
	Total Fall...	0·166 inch.	65 ft. above ground.
		1·419 inch.	15 in. above ground.

(Being 5·316 inches less than that of the same month on an average of the preceding 17 years.)

Evaporation	Total Amount	7·336 inches.
Ozone ...	Mean Amount	6·9

(Being 2·0 greater than that in the same month on an average of the preceding 16 years.)

Electricity...	Number of Days Lightning	5
Cloudy Sky...	Mean Amount	5·8
	Number of Clear Days ...	1
Meteors ...	Number Observed ...	4

Remarks.

The drought of the past months still continues generally, a few stations only have had useful rain, and the effects of the continued dry weather are most serious; cattle and sheep are said to be dying in immense numbers, and fears are entertained that no grass can grow before the frosts, even if rain comes at once. At Sydney the total rainfall for the month was only 0·419 inch, or less than that for any March during the last 36 years, or the whole period on record. Evaporation has also been very great, and the temperature 2·9 above the average.

GOVERNMENT OBSERVATORY, SYDNEY.

LATITUDE 33° 51′ 41″; LONGITUDE 10h 4m 40s; MAGNETIC VARIATION 9° 32′ 45″ East.

APRIL, 1876.—GENERAL ABSTRACT.

Barometer... At 32° Faht.	Highest Reading ...	... 30·244 inches on the 10th, at 9 p.m.	
	Lowest Reading ...	... 29·461 „ on the 5th, at 1·45 p.m.	
	Mean Height ...	... 29·832	

(Being 0·167 inch less than that in the same month on an average of the preceding 17 years.)

Wind ...	Greatest Pressure...	... 9·7 lbs. on the 9th.	
	Mean Pressure ...	... 0·5 lb.	
	Number of Days Calm ...	0	
	Prevailing Direction ...	W.N.W.	

(Prevailing direction during the same month for the preceding 17 years W.)

Temperature	Highest in the Shade ...	87·0	... On th 5th.
	Lowest in the Shade ...	52·6	... On the 18th.
	Greatest Range	27·0	... On the 4th.
	Highest in the Sun ...	121·7	... On the 5th.
	Highest in Black Box with Glass Top	172·5	... On the 4th.
	Lowest on the Grass ...	39·5	... On the 30th.
	Mean Diurnal Range ...	15·5	
	Mean in the Shade ...	65·8	

(Being 0·8 greater than that of the same month on an average of the preceding 17 years.)

Humidity ...	Greatest Amount... ...	100·0	... On the 13th.
	Least	32·0	... On the 5th.
	Mean	72·7	

(Being 5·4 less than that of the same month on an average of the preceding 17 years.)

Rain... ...	Number of Days	10 rain and 2 dew.	
	Greatest Fall	1·685 inch.	On the 14th.
	Total Fall	4·637 inch.	65 ft. above ground.
		5·246 inch.	15 in. above ground.

(Being 2·108 inches less than that of the same month on an average of the preceding 16 years.)

Evaporation	Total Amount	4·850 inches.
Ozone ...	Mean Amount	6·9

Being 1·9 greater than that in the same month on an average of the preceding 17 years.)

Electricity...	Number of Days Lightning	8
Cloudy Sky...	Mean Amount	4·5
	Number of Clear Days ...	4
Meteors ...	Number Observed ...	6

Remarks.

The temperature of the first few days of the month was very high, and reached the extreme degree for this month 87·0° on the 5th. The dry weather continued to the 7th, when welcome rain began at northern stations and gradually extended southwards. It was however principally confined to the coast districts, and very little fell west of the dividing range. The greatest fall was 19·690 inches at Port Macquarie, of this 9·750 fell on the 15th. Places reached by the rain had in most cases sufficient to relieve the drought, but to the west the drought still continues, and the losses from want of water and grass are very great; at Wilcannia and Upper Darling, teams cannot travel for want of water.

GOVERNMENT OBSERVATORY, SYDNEY.

LATITUDE 33° 51′ 41″; LONGITUDE 10h 4m 46s; MAGNETIC VARIATION 9° 32′ 45″ East.

MAY, 1876.—GENERAL ABSTRACT.

Barometer ... At 32° Faht.	Highest Reading... ...	30·345 inches on the 15th, at 8·55 a.m.	
	Lowest Reading... ...	29·537 ,, on the 30th, at 11 a.m.	
	Mean Height	29·999	

(Being 0·072 inch greater than that in the same month on an average of the preceding 17 years.)

Wind ...	Greatest Pressure ...	12·5 lbs. on the 7th.	
	Mean Pressure	0·5 lb.	
	Number of Days Calm ...	2	
	Prevailing Direction ...	W.	

(Prevailing direction during the same month for the preceding 17 years W.)

Temperature	Highest in the Shade ...	76·6	On the 12th.
	Lowest in the Shade ...	49·8	On the 14th.
	Greatest Range	17·3	On the 3rd.
	Highest in the Sun ...	111·3	On the 22nd.
	Highest in Black Box with Glass Top ...	155·6	On the 13th.
	Lowest on the Grass ...	40·1	On the 10th.
	Mean Diurnal Range ...	10·4	
	Mean in the Shade ...	60·1	

(Being 1·7 greater than that of the same month on an average of the preceding 17 years.)

Humidity ...	Greatest Amount ...	100·0	On the 7th and 20th.
	Least	51·0	On the 13th.
	Mean	82·4	

(Being 6·6 greater than that of the same month on an average of the preceding 17 years.)

Rain... ...	Number of Days... ...	21 rain and 2 dew.	
	Greatest Fall	2·815 inches.	On the 22nd.
	Total Fall	10·435 inches.	65 ft. above ground.
		13·166 inches.	15 in. above ground.

(Being 8·525 inches greater than that of the same month on an average of the preceding 17 years.)

Evaporation	Total Amount	1·795 inches.	
Ozone ...	Mean Amount	7·5	

(Being 2·8 greater than that in the same month on an average of the preceding 16 years.)

Electricity...	Number of Days Lightning	2	
Cloudy Sky...	Mean Amount	6·5	
	Number of Clear Days ...	7	
Meteors ...	Number Observed ...		

Remarks.

The weather this month has been unusually mild at Sydney, with abundant rains generally over the Colony, excepting the southern and south-western parts, where the drought unfortunately still prevails. On the coast the rains have been specially heavy, reaching a maximum of 19 inches about Port Macquarie. 17 inches fell at Cape George, and 13 inches at Sydney. At other stations, with the exception mentioned, the amount has varied from 3 inches to 12 inches. The mean temperature at Sydney was 1·7° greater than the average, and the warm weather at the early part of the month, combined with the April rains, brought many of the fruits into blossom (on the 15th), which it is feared will prevent them blossoming in spring.

GOVERNMENT OBSERVATORY, SYDNEY.

LATITUDE 33° 51′ 41″; LONGITUDE 10h 4m 46s; MAGNETIC VARIATION 9° 32′ 45″ East.

JUNE, 1876.—GENERAL ABSTRACT.

Barometer ... At 32° Faht.	Highest Reading	30·418 inches on the 19th, at 10·30 a.m.
	Lowest Reading	29·446 „ on the 16th, at 12 noon.
	Mean Height	29·957

(Being 0·039 inch greater than that in the same month on an average of the preceding 17 years.)

Wind ...	Greatest Pressure... ...	15·7 lbs. on the 17th.
	Mean Pressure	0·7 lb.
	Number of Days Calm ...	0
	Prevailing Direction ...	W.N.W.

(Prevailing direction during the same month for the preceding 17 years W.)

Temperature	Highest in the Shade ...	68·8	On the 15th.
	Lowest in the Shade ...	41·1	On the 19th.
	Greatest Range	21·3	On the 19th.
	Highest in the Sun ...	102·7	On the 15th.
	Highest in Black Box with Glass Top	132·6	On the 15th.
	Lowest on the Grass ...	35·5	On the 19th.
	Mean Diurnal Range ...	13·7	
	Mean in the Shade ...	54·1	

(Being 0·7 less than that of the same month on an average of the preceding 17 years.)

Humidity ...	Greatest Amount... ...	100·0	On the 20th, 25th, 27th, and 29th
	Least	43·0	On the 15th.
	Mean	76·7	

(Being 0·4 less than that of the same month on an average of the preceding 17 years.)

Rain... ...	Number of Days	7 rain and 6 dew.	
	Greatest Fall	2·028 inches.	On the 27th.
	Total Fall...	3·495 inches.	65 ft. above ground.
		4·419 inches.	15 in. above ground.

(Being 1·456 inches less than that of the same month on an average of the preceding 17 years.)

Evaporation	Total Amount	2·196 inches.
Ozone ...	Mean Amount	7·5

(Being 2·2 greater than that in the same month on an average of the preceding 17 years.)

Electricity...	Number of Days Lightning	4
Cloudy Sky...	Mean Amount	3·5
	Number of Clear Days ...	3
Meteors ...	Number Observed ...	2

Remarks.

The weather during the month has been clear and cold, with barometer rather above the average, and prevailing westerly winds. Rain fell at Sydney on seven days; but the amount is 1·456 inch below the average of this month. The excessive quantity of ozone, 2·2 above the average is remarkable, considering the prevalence of westerly winds. Generally along the coast a moderate quantity of rain has fallen, ranging from 2 to 9 inches; but inland the month has been very dry, and in many places the drought still continues. The minimum barometer at Sydney occurred on the 16th, followed by a cold W.N.W. gale and lightning at night. On the 17th snow fell at Orange, Goulburn, and Cooma. On the 22nd a very high tide visited Sydney.

GOVERNMENT OBSERVATORY, SYDNEY.

LATITUDE 33° 51′ 41″; LONGITUDE 10h 4m 46s; MAGNETIC VARIATION 9° 32′ 45″ East.

JULY, 1876.—GENERAL ABSTRACT.

Barometer ... At 32° Faht.	Highest Reading	30·318 inches on the 31st, at 8 a.m.
	Lowest Reading	29·481 „ on the 27th, at 2 a.m.
	Mean Height	29·945

(Being 0·007 inch greater than that in the same month on an average of the preceding 17 years.)

Wind ...	Greatest Pressure ...	17·4 lbs. on the 21st.
	Mean Pressure	1·5 lb.
	Numbers of Days Calm ...	0
	Prevailing Direction ...	W.N.W.

(Prevailing direction during the same month for the preceding 17 years W.N.W.)

Temperature	Highest in the Shade ...	61·9	On the 11th.
	Lowest in the Shade ...	39·1	On the 31st.
	Greatest Range	22·6	On the 31st.
	Highest in the Sun ...	99·9	On the 9th.
	Highest in Black Box with Glass Top	131·6	On the 24th.
	Lowest on the Grass ...	33·3	On the 31st.
	Mean Diurnal Range ...	11·3	
	Mean in the Shade ...	52·8	

(Being 0·5 greater than that of the same month on an average of the preceding 17 years.)

Humidity ...	Greatest Amount... ...	100·0	On the 13th, 17th, and 22nd.
	Least	52·0	On the 29th.
	Mean	80·4.	

(Being 6·6 greater than that of the same month on an average of the preceding 17 years.)

Rain... ...	Number of Days	18 rain and 5 dew.
	Greatest Fall	1·675 inches, on the 14th.
	Total Fall...	4·370 inches. 65 ft. above ground. 6·741 inches. 15 in. above ground.

(Being 2·602 inches greater than that of the same month on an average of the preceding 17 years.)

Evaporation	Total Amount	2·331 inches.
Ozone ...	Mean Amount	7·8

(Being 2·7 greater than that in the same month on an average of the preceding 15 years.)

Electricity...	Number of Days Lightning	5
Cloudy Sky...	Mean Amount	5·9
	Number of Clear Days ...	3
Meteors ...	Number Observed ...	7

Remarks.

The month has been wet and windy at Sydney, and generally along the coast districts. In the western districts the rainfall, if any, has been small, and at some places the drought still continues. On the 13th and 14th a strong easterly gale, with deluges of rain, came on, and extended from Queensland right down the coast to Eden; in some parts of Queensland the floods were higher than ever before known. There were high floods in the Clarence (here the greatest on record, the city was almost all under water) and Macleay Rivers on 15th, and moderate floods in the Hunter on 16th. There was a terrific fall of rain in New England, and at Tenterfield upwards of nine inches fell in one day. There was a partial return of this weather on 21st and 22nd. At 4 a.m of 19th a very severe shock of earthquake in New Zealand.

GOVERNMENT OBSERVATORY, SYDNEY.

LATITUDE 33° 51′ 41″; LONGITUDE 10h 4m 46s; MAGNETIC VARIATION 9° 32′ 45″ East.

AUGUST, 1876.—GENERAL ABSTRACT.

Barometer ... At 32° Faht.	Highest Reading	30·333 inches on the 1st, at 11 a.m.
	Lowest Reading	29·419 „ on the 24th, at 9 p.m.
	Mean Height	29·956

(Being 0·013 inch greater than that in the same month on an average of the preceding 17 years.)

Wind ...	Greatest Pressure ...	12·5 lbs. on the 7th and 17th.
	Mean Pressure	0·7 lb.
	Number of Days Calm ...	0
	Prevailing Direction ...	W.N.W.

(Prevailing direction during the same month for the preceding 17 years W.)

Temperature	Highest in the Shade ...	72·1	On the 31st.
	Lowest in the Shade ...	40·8	On the 19th.
	Greatest Range	23·5	On the 31st.
	Highest in the Sun ...	109·0	On the 30th and 31st.
	Highest in Black Box with Glass Top ...	162·5	On the 31st.
	Lowest on the Grass ...	34·8	On the 19th.
	Mean Diurnal Range ...	14·6	
	Mean in the Shade ...	54·8	

(Being 0·3 greater than that of the same month on an average of the preceding 17 years.)

Humidity ...	Greatest Amount... ...	100·0	On the 4th, 15th, and 23rd.
	Least	48·0	On the 31st.
	Mean	76·5	

(Being 6·5 greater than that of the same month on an average of the preceding 17 years.)

Rain... ...	Number of Days	14 rain and 5 dew.
	Greatest Fall	0·552 inch, on the 23rd.
	Total Fall...	0·936 inch. 65 ft. above ground.
		1·295 inch. 15 in. above ground.

(Being 1·546 inch greater than that of the same month on an average of the preceding 17 years.)

Evaporation	Total Amount	3·096 inches.
Ozone ...	Mean Amount	7·7

(Being 2·8 greater than that in the same month on an average of the preceding 15 years.)

Electricity...	Number of Days Lightning	8
Cloudy Sky...	Mean Amount	4·5
	Number of Clear Days ...	3
Meteors ...	Number Observed ...	3

Remarks.

The weather has been dry and hot, with prevalent westerly winds during the month. At Sydney the rainfall is less than half the average for the month, and at all stations except Orange the rainfall has been small. Lightning has been frequent at Sydney, and the Zodiacal light has been very bright, on the 12th extending to an altitude of 45°

GOVERNMENT OBSERVATORY, SYDNEY.

LATITUDE 33° 51′ 41″; LONGITUDE 10h 4m 46s; MAGNETIC VARIATION 9° 32′ 45″ East.

SEPTEMBER, 1876.—GENERAL ABSTRACT.

Barometer ... At 32° Faht.	Highest Reading	30·174 inches on the 23rd.	
	Lowest Reading	29·082 „ on the 14th.	
	Mean Height	29·828	

(Being 0·061 less than that in the same month on an average of the preceding 17 years.)

Wind ...	Greatest Pressure... ...	117·0 lbs. on the 10th.	
	Mean Pressure	1·3 lb.	
	Number of Days Calm ...	0	
	Prevailing Direction ...	W.N.W.	

(Prevailing direction during the same month for the preceding 17 years W.)

Temperature	Highest in the Shade ...	81·3	On the 21st.
	Lowest in the Shade ...	43·4	On the 13th.
	Greatest Range	28·9	On the 19th.
	Highest in the Sun ...	117·8	On the 19th.
	Highest in Black Box with Glass Top	188·5	On the 19th.
	Lowest on the Grass ...	40·1	On the 17th.
	Mean Diurnal Range ...	14·6	
	Mean in the Shade ...	59·2	

(Being 0·7 greater than that of the same month on an average of the preceding 17 years.)

Humidity ...	Greatest Amount... ...	98·0	On the 29th.
	Least	35·0	On the 1st.
	Mean	70·3	

(Being 1·5 greater than that of the same month on an average of the preceding 17 years.)

Rain... ...	Number of Days	11 rain and 3 dew.	
	Greatest Fall	1·967 inches.	On the 11th.
	Total Fall	1·993 inches.	65 ft. above ground.
		3·505 inches.	15 in. above ground.

(Being 1·279 inches greater than that of the same month on an average of the preceding 17 years.)

Evaporation	Total Amount	4·903 inches.
Ozone ...	Mean Amount	7·6

(Being 2·4 greater than that in the same month on an average of the preceding 16 years.)

Electricity...	Number of Days Lightning	4
Cloudy Sky...	Mean Amount	5·0
	Number of Clear Days ...	2
Meteors ...	Number Observed ...	1

Remarks.

The dry weather continued until the 10th instant, when a very severe storm of wind and rain came from the southward along the coast, and inland from the south as far as the Lachlan River. The interior to north of this is still suffering severely from drought.

GOVERNMENT OBSERVATORY, SYDNEY.

LATITUDE 33° 51′ 41″; LONGITUDE 10h 4m 46s; MAGNETIC VARIATION 9° 32′ 45″ East.

OCTOBER, 1876.—GENERAL ABSTRACT.

Barometer ... At 32° Faht.	Highest Reading	30·004 inches on the 3rd.	
	Lowest Reading	29·386 „ on the 20th.	
	Mean Height	29·721	

(Being ·120 greater than that in the same month on an average of the preceding 17 years.)

Wind ...	Greatest Pressure ...	12·5 lbs. on the 6th.	
	Mean Pressure	0·7 lb.	
	Number of Days Calm ...	0	
	Prevailing Direction ...	W.N.W.	

(Prevailing direction during the same month for the preceding 17 years, N.E.)

Temperature	Highest in the Shade ...	82·1	On the 23rd.
	Lowest in the Shade ...	48·2	On the 3rd.
	Greatest Range	24·2	On the 17th.
	Highest in the Sun ...	121·9	On the 23rd.
	Highest in Black Box with Glass Top	203·4	On the 23rd.
	Lowest on the Grass ...	40·1	On the 1st.
	Mean Diurnal Range ...	14·6	
	Mean in the Shade ...	63·1	

(Being 0·5 less than that of the same month on an average of the preceding 17 years.)

Humidity ...	Greatest Amount... ...	97·0	On the 4th.
	Least	37·0	On the 12th.
	Mean	73·7	

(Being 5·5 greater than that of the same month on an average of the preceding 17 years.)

Rain... ...	Number of Days... ...	14	
	Greatest Fall	0·840 inch.	On the 8th.
	Total Fall...	1·956 „	65 ft. above ground.
		2·841 inches.	15 in. above ground.

(Being 0·316 greater than that of the same month on an average of the preceding 17 years.)

Evaporation	Total Amount	5·155 inches.	
Ozone ...	Mean Amount	6·0	

(Being 0·7 than that in the same month on an average of the preceding 16 years.)

Electricity...	Number of Days Lightning	13	
Cloudy Sky..	Mean Amount	5·0	
	Number of Clear Days ...	0	
Meteors ...	Number Observed ...	3	

Remarks.

Nice rains fell along the coast about the middle of the month. Inland the weather has been dry, and a remarkable phenomenon has occurred with regard to cattle and horses; those with white patches, or all white, have been attacked by a kind of aphis and all the white hair removed, aphis has also been very prevalent on vegetables.

GOVERNMENT OBSERVATORY, SYDNEY.

LATITUDE 33° 51′ 41″; LONGITUDE 10h 4m 46s; MAGNETIC VARIATION 9° 32′ 45″ East

NOVEMBER, 1876.—GENERAL ABSTRACT.

Barometer ... At 32° Faht.	Highest Reading	30·122 inches on the 30th, at 10 a.m.
	Lowest Reading	29·254 „ on the 19th, at 4 a.m.
	Mean Height	29·630

(Being 0·191 inch less than that in the same month on an average of the preceding 17 years.

Wind ...	Greatest Pressure... ...	15·1 lbs. on the 5th and 25th.
	Mean Pressure	1·1 lb.
	Number of Days Calm ...	0
	Prevailing Direction ...	S.S.W.

(Prevailing direction during the same month for the preceding 17 years N.E.)

Temperature	Highest in the Shade ...	92·8	... On the 12th.
	Lowest in the Shade ...	50·8	... On the 25th.
	Greatest Range	28·6	... On the 7th.
	Highest in the Sun ...	127·4	... On the 12th.
	Highest in Black Box with Glass Top	203·2	... On the 12th.
	Lowest on the Grass ...	44·5	... On the 25th.
	Mean Diurnal Range ...	13·7	
	Mean in the Shade ...	67·3	

(Being 0·9 greater than that of the same month on an average of the preceding 17 years.)

Humidity ...	Greatest Amount... ...	100·0	On the 17th and 18th.
	Least	38·0	On the 10th.
	Mean	73·0	

(Being 3·9 greater than that of the same month on an average of the preceding 17 years.)

Rain... ...	Number of Days	13
	Greatest Fall	2·108 inches on the 17th.
	Total Fall	3·468 inches. 65 ft. above ground.
		4·824 inches. 15 in. above ground.

(Being 1·328 inches greater than that of the same month on an average of the preceding 17 years.)

Evaporation	Total Amount	6·804 inches.
Ozone ...	Mean Amount	6·1

(Being 1·1 greater than that in the same month on an average of the preceding 16 years.)

Electricity...	Number of Days Lightning	11
Cloudy Sky..	Mean Amount	7·0
	Number of Clear Days ...	2
Meteors ...	Number Observed ...	3

Remarks.

The mean temperature this month is 0·9 above the average, and along the coast valuable rains have fallen, but inland the drought is still pressing in many places. Trees did blossom this spring. (See note in May.)

GOVERNMENT OBSERVATORY, SYDNEY.

LATITUDE 33° 51′ 41″ ; LONGITUDE 10h 4m 46s ; MAGNETIC VARIATION 9° 32′ 45″ East.

DECEMBER, 1876.—GENERAL ABSTRACT.

Barometer ... At 32° Faht.	Highest Reading	30·106 inches on the 18th, at 10 a.m.
	Lowest Reading	29·251 „ on the 26th, at 2 a.m.
	Mean Height	29·785

(Being 0·035 inch greater than that in the same month on an average of the preceding 17 years.)

Wind ...	Greatest Pressure ...	14·6 lbs. on the 16th.
	Mean Pressure	0·9 lb.
	Number of Days Calm ...	0
	Prevailing Direction ...	E.N.E.

(Prevailing direction during the same month for the preceding 17 years, N.E.)

Temperature	Highest in the Shade ...	88·3	On the 15th.
	Lowest in the Shade ...	53·4	On the 4th.
	Greatest Range	24·5	On the 14th.
	Highest in the Sun ...	126·9	On the 16th.
	Highest in Black Box with Glass Top	206·5	On the 18th.
	Lowest on the Grass ...	49·1	On the 2nd.
	Mean Diurnal Range ...	14·3	
	Mean in the Shade ...	70·0	

(Being 0·6 greater than that of the same month on an average of the preceding 17 years.)

Humidity ...	Greatest Amount... ...	94·0	On the 12th.
	Least	36·0	On the 27th.
	Mean	68·8	

(Being 1·1 greater than that of the same month on an average of the preceding 17 years.)

Rain... ...	Number of Days	9	
	Greatest Fall	0·290 inch.	On the 27th.
	Total Fall...	0·228 inch.	65 ft above ground.
		0·453 inch.	15 in. above ground.

(Being 1·857 inches less than that of the same month on an average of the preceding 17 years.)

Evaporation	Total Amount	8·566 inches.
Ozone ...	Mean Amount	6·1

(Being 1·6 greater than that in the same month on an average of the preceding 16 years.)

Electricity...	Number of Days Lightning	6
Cloudy Sky...	Mean Amount	5·6
	Number of Clear Days ...	4
Meteors ...	Number Observed ..	4

Remarks.

The temperature this month has been high, and the barometer rather above the average. Rain has been light generally, except in New England where it has been abundant. To south and west inland the continued dry weather is severely felt.

INDEX.

Sydney: Charles Potter, Acting Government Printer.—1877.

ROYAL SOCIETY OF NEW SOUTH WALES.

JOURNAL

AND

PROCEEDINGS

OF THE

ROYAL SOCIETY

OF

NEW SOUTH WALES,

1877.

VOL. XI.

EDITED BY

A. LIVERSIDGE,
Professor of Geology and Mineralogy in the University of Sydney.

THE AUTHORS OF PAPERS ARE ALONE RESPONSIBLE FOR THE STATEMENTS MADE AND THE OPINIONS EXPRESSED THEREIN.

AGENTS FOR THE SOCIETY:
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SYDNEY: THOMAS RICHARDS, GOVERNMENT PRINTER.

Sm 1878.

NOTICE.

THE ROYAL SOCIETY of New South Wales originated in 1821 as the "Philosophical Society of Australia"; after an interval of inactivity, it was resuscitated in 1850, under the name of the "Australian Philosophical Society," by which title it was known until 1856, when the name was changed to the "Philosophical Society of New South Wales"; and finally, in May, 1866, by the sanction of Her Most Gracious Majesty the Queen, it assumed its present title.

CORRIGENDA.

Page.	*Line.*	
11	18	For "Gŏningen" *read* "Gŏttingen"
26	21	For "assume very definite limit" *read* "assumes very definite limits"
70	41	Before "Victorian" *insert* "2."
131	18	For "Warrnambool" *read* "Warnambool"
133	36	After "last" *delete* the period and *add* a comma
134	2	For "*Speroporina*" *read* "*Spiroporina*"
"	32	After "it" *insert* "was"
139	9	For "M. FIDENS" *read* "M. BIDENS."
"	21	*Delete* "MS."
"	23	After "to" *add* "but described in 1861 in the *Quart. Jour. Microscopical Science*, N. Series, I, p. 79."
140	6	For "fig." *read* "w.-cut."
141	27	*Delete* the word "Genus"
"	35	For "*Hasstiana*" *read* "*Haastiana.*"
142	7	For "*Melneina*" *read* "*Milneana.*"
143	8	For "*Melneina*" *read* "*Milneana.*"
"	9	For "*Hoastiana*" *read* "*Haastiana.*"

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VOLUME XI.

The Royal Society of New South Wales.

OFFICERS FOR 1877–8.

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&c., &c., &c.

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WEBB, W. H.

FUNDAMENTAL RULES.

Object of the Society.

1. The object of the Society is to receive at its stated meetings original papers on subjects of Science, Art, Literature, and Philosophy, and especially on such subjects as tend to develop the resources of Australia, and to illustrate its Natural History and Productions.

President.

2. The Governor of New South Wales shall be *ex officio* the President of the Society.

Other Officers.

3. The other Officers of the Society shall consist of two Vice-Presidents, a Treasurer, and two or more Secretaries, who, with six other Members, shall constitute a Council for the management of the affairs of the Society.

Election of Officers.

4. The Vice-Presidents, Treasurer, Secretaries, and the six other Members of Council, shall be elected annually at the General Meeting in the month of May.

Vacancies during the year.

5. Any vacancies occurring in the Council of Management during the year may be filled up by the Council.

Fees.

6. The entrance money paid by Members on their admission shall be One Guinea; and the annual subscription shall be One Guinea, payable in advance.

The sum of Ten Pounds may be paid at any time as a composition for the ordinary annual payment for life.

Honorary Members.

7. The Honorary Members of the Society shall be persons who have been eminent benefactors to this or some other of the Australian Colonies, or distinguished patrons and promoters of the objects of the Society. Every person proposed as an Honorary Member must be recommended by the Council and elected by the Society. Honorary Members shall be exempted from payment of fees and contributions; they may attend the meetings of the Society, and they shall be furnished with copies of Transactions and Proceedings published by the Society, but they shall have no right to hold office, to vote, or otherwise interfere in the business of the Society.

Confirmation of By-laws.

8. By-laws proposed by the Council of Management shall not be binding until ratified by a General Meeting.

Alteration of Fundamental Rules.

9. No alteration of or addition to the Fundamental Rules of the Society shall be made unless carried at two successive general meetings.

BY-LAWS

Passed at a General Meeting of the Society, held June 7th, 1876.

Ordinary General Meetings.

I. An Ordinary General Meeting of the Royal Society, to be convened by public advertisement, shall take place at 8 p.m., on the first Wednesday in every month, during the last eight months of the year; subject to alteration by the Council with due notice. These meetings will be open for the reading of papers, and the discussion of subjects of every kind if brought forward in conformity with the Fundamental Rules and By-laws of the Society.

Annual General Meeting.—Annual Reports.—Election of Officers.

II. A General Meeting of the Society shall be held annually in May, to receive a Report from the Council on the state of the Society, and to elect Officers for the ensuing year. The Treasurer shall also at this meeting present the annual financial statement.

Election of the Officers and Council.

III. The Officers and other members of the Council shall be elected annually *by ballot* at the Annual General Meeting to be held in May.

IV. It shall be the duty of the Council each year to prepare a list containing the names of members whom they recommend for election to the respective offices of Vice-Presidents and Hon. Secretaries and Hon. Treasurer, together with the names of six other members whom they recommend for election as ordinary members of Council. The names thus recommended shall be proposed at one meeting of the Council, and agreed to at a subsequent meeting.

V. Each member present at the General Annual Meeting shall have the power to alter the list of names recommended by the Council, by adding to it the names of any eligible members not already included in it and removing from it an equivalent number of names, and he shall use this list with or without such alterations as a balloting list at the election of Officers and Council.

Council Meetings.

VI. Meetings of the Council of Management shall take place on the last Wednesday in every month, and on such other days as the Council may determine.

Absence from Meetings of Council.—Quorum.

VII. Any member of the Council absenting himself from three consecutive meetings of the Council, without giving a satisfactory explanation in writing, shall be considered to have vacated his office, and the election of a member to fill his place shall be proceeded with at the next Council meeting in accordance with Fundamental Rule V. No business shall be transacted at any meeting of the Council unless three members are present.

Duties of Secretaries.

VIII. The Honorary Secretaries shall perform, or shall cause the Assistant Secretary to perform, the following duties :—

1. Conduct the correspondence of the Society and Council.
2. Attend the General Meetings of the Society and the meetings of the Council, to take minutes of the proceedings of such meetings, and at the commencement of such to read aloud the minutes of the preceding meeting.
3. At the Ordinary Meetings of the members, to announce the presents made to the Society since their last meeting; to read the certificates of candidates for admission to the Society, and such original papers communicated to the Society as are not read by their respective authors, and the letters addressed to it.

4. To make abstracts of the papers read at the Ordinary General Meetings, to be inserted in the Minutes and printed in the Proceedings.
5. To edit the Transactions of the Society, and to superintend the making of an Index for the same.
6. To be responsible for the arrangement and safe custody of the books, maps, plans, specimens, and other property of the Society.
7. To make an entry of all books, maps, plans, pamphlets, &c., in the Library Catalogue, and of all presentations to the Society in the Donation Book.
8. To keep an account of the issue and return of books, &c., borrowed by members of the Society, and to see that the borrower, in every case, signs for the same in the Library Book.
9. To address to every person elected into the Society a printed copy of the Forms Nos. 2 and 3 (in the Appendix), together with a list of the members, a copy of the Fundamental Rules and By-laws, and a card of the dates of meeting; and to acknowledge all donations made to the Society, by Form No. 5.
10. To cause due notice to be given of all Meetings of the Society and Council.
11. To be in attendance at 4 p.m. on the afternoon of Wednesday in each week during the session.
12. To keep a list of the attendances of the members of the Council at the Council Meetings and at the Ordinary General Meetings of the members of the Society, in order that the same may be laid before the Society at the Annual General Meeting held in the month of May.

The Honorary Secretaries shall, by mutual agreement, divide the performance of the duties above enumerated.

The Honorary Secretaries shall, by virtue of their office, be members of all Committees appointed by the Council.

Candidates for admission.

IX. Every candidate for admission as an ordinary member of the Society shall be recommended according to a prescribed form, by not less than three members, to two of whom he must be personally known.

Election of new Members.

X. The names of such candidates, with the names of their supporters, shall be read by one of the Secretaries at an Ordinary General Meeting of the Society. The vote as to admission to take place by ballot at the next subsequent meeting. At the ballot the assent of at least four-fifths of the members voting shall be requisite for the admission of the candidate.

New Members to be informed of their election.

XI. Every new member shall receive due notification of his election, and be supplied with a copy of the obligation (No. 3 in Appendix), together with a copy of the Fundamental Rules and By-laws of the Society, a list of members, and a card of the dates of meeting.

Members whose subscriptions are unpaid to enjoy no privileges.

XII. An elected member shall not be entitled to attend the meetings nor to enjoy any privilege of the Society, nor shall his name be printed in the list of the Society, until he shall have paid his admission fee and first annual subscription, and have returned to the Secretaries the obligation signed by himself.

Members shall sign Rules—Formal admission.

XIII. Every member who has complied with the preceding By-laws shall at the first Ordinary General Meeting at which he shall be present, sign a duplicate of the aforesaid obligation in a book to be kept for that purpose, after which he shall be presented by some member to the Chairman, who, addressing him by name, shall say :—"By the authority and in the name of the Royal Society of New South Wales I admit you a member thereof."

Annual subscriptions, when due.

XIV. Annual subscriptions shall become due on the 1st of May for the year then commencing. The entrance fee and first year's subscription of a new member shall become due on the day of his election.

Subscriptions in arrears.

XV. Members who have not paid their subscriptions for the current year, on or before the 31st of May, shall be informed of the fact by the Hon. Treasurer.

And at the meeting held in July, and at all subsequent meetings for the year, a list of the names of all those members who are in arrears with their annual subscriptions shall be suspended in the Rooms of the Society. Members shall in such cases be informed that their names have been thus posted.

Resignation of Members.

XVI. No member shall be at liberty to withdraw from the Society without previously giving notice to one of the Secretaries of his desire to withdraw, and returning all books or other property belonging to the Society. Members will be considered liable for the payment of all subscriptions due from them up to the date at which they may give notice of their intention to withdraw from the Society.

Expulsion of Members.

XVII. A majority of members present at any ordinary meeting shall have power to expel an obnoxious member from the Society, provided that a resolution to that effect has been moved and seconded at the previous ordinary meeting, and that due notice of the same has been sent in writing to the member in question, within a week after the meeting at which such resolution has been brought forward.

Contributions to the Society.

XVIII. Contributions to the Society, of whatever character, must be sent to one of the Secretaries, to be laid before the

Council of Management. It will be the duty of the Council to arrange for promulgation and discussion at an Ordinary Meeting such communications as are suitable for that purpose, as well as to dispose of the whole in the manner best adapted to promote the objects of the Society.

Order of Business.

XIX. At the Ordinary General Meetings the business shall be transacted in the following order, unless the Chairman specially decide otherwise:—

1—Minutes of the preceding Meeting.
2—New Members to enrol their names and be introduced.
3—Ballot for the election of new Members.
4—Candidates for membership to be proposed.
5—Business arising out of Minutes.
6—Communications from the Council.
7—Communications from the Sections.
8—Donations to be laid on the Table and acknowledged.
9—Correspondence to be read.
10—Motions from last Meeting.
11—Notices of Motion for the next Meeting to be given in.
12—Papers to be read.
13—Discussion.
14—Notice of Papers for the next Meeting.

Admission of Visitors.

XX. Every ordinary member shall have the privilege of admitting two friends as visitors to an Ordinary General Meeting of the Society, on the following conditions:—

1. That the name and residence of the visitors, together with the name of the member introducing them, be entered in a book at the time.
2. That they shall not have attended two consecutive meetings of the Society in the current year.

The Council shall have power to introduce visitors, irrespective of the above restrictions.

Management of Funds.

XXI. The funds of the Society shall be lodged at a Bank named by the Council of Management. Claims against the Society, when approved by the Council, shall be paid by the Treasurer.

Money Grants.

XXII. Grants of money in aid of scientific purposes from the funds of the Society—to Sections or to members—shall expire on the 1st of November in each year. Such grants, if not expended, may be re-voted.

XXIII. Such grants of money to Committees and individual members shall not be used to defray any personal expenses which a member may incur.

Audit of Accounts.

XXIV. Two Auditors shall be appointed annually, at an Ordinary Meeting, to audit the Treasurer's Accounts. The accounts as audited to be laid before the Annual Meeting in May.

Property of the Society to be vested in the Vice-Presidents, &c.

XXV. All property whatever belonging to the Society shall be vested in the Vice-Presidents, Hon. Treasurer, and Hon. Secretaries for the time being, in trust for the use of the Society; but the Council shall have control over the disbursements of the funds and the management of the property of the Society.

Library.

XXVI. The Members of the Society shall have access to, and shall be entitled to borrow books from the Library, under such regulations as the Council may think necessary.

Museum.

XXVII. It shall be one of the objects of the Society to form a Museum.

Branch Societies.

XXVIII. The Society shall have power to form Branch Societies in other parts of the Colony.

SECTIONS.

XXIX. To allow those members of the Society who devote attention to particular branches of science fuller opportunities and facilities of meeting and working together with fewer formal restrictions than are necessary at the general Monthly Meetings of the Society,—Sections or Committees may be established in the following branches of science:—

Section A.—Astronomy, Meteorology, Physics, Mathematics, and Mechanics.

Section B.—Chemistry and Mineralogy, and their application to the Arts and Agriculture.

Section C.—Geology and Palæontology.

Section D.—Biology, *i.e.*, Botany and Zoology, including Entomology.

Section E.—Microscopical Science.

Section F.—Geography and Ethnology.

Section G.—Literature and the Fine Arts, including Architecture.

Section H.—Medical.

Section I.—Sanitary and Social Science and Statistics.

Reports from Sections.

XXX. There shall be for each Section a Chairman to preside at the meetings, and a Secretary to keep minutes of the proceedings, who shall jointly prepare and forward to the Hon. Secretaries of the Society, on or before the 7th of November in each year, a report of the proceedings of the Section during that year, in order that the same may be transmitted to the Council.

Section Committees—Card of Meetings.

XXXI. The first meeting of each Section shall be appointed by the Council. At that meeting the members shall elect their own Chairman, Secretary, and a Committee of four; and arrange the days and hours of their future meetings. A card showing the dates of each meeting for the current year shall be printed for distribution amongst the members of the Society.

Money Grants to Sections.

XXXII. By application to the Council, grants of money may be made out of the General Funds of the Society to the Sections.

Membership of Sections.

XXXIII. No person who is not a member of the Society shall have the privilege of joining any of the Sections.

THE LIBRARY.

1. During the Session, the Library shall be open for consultation, and for the issue and return of books, between 4 and 6 p.m. on the afternoon of each Wednesday, and between 7 and 10 p.m. on the evenings of Monday, Wednesday, and Friday.

2. No book shall be issued without being signed for in the Library Book.

3. Members are not allowed to have more than three volumes at a time from the Library, without special permission from one of the Honorary Secretaries, nor to retain a book for a longer period than fourteen days; but when a book is returned by a member it may be borrowed by him again, provided it has not been bespoken by any other member. Books which have been bespoken shall circulate in rotation, according to priority of application.

4. Scientific Periodicals and Journals are not to be borrowed until the volumes are completed and bound.

5. Members retaining books longer than the time specified shall be subject to a fine of sixpence per week for each volume.

6. The books which have been issued shall be called in by the Secretaries twice a year; and in the event of any book not being returned on those occasions, the member to whom it was issued shall be answerable for it, and shall be required to defray the cost of replacing same.

Form No. 1.

ROYAL SOCIETY OF NEW SOUTH WALES.

Certificate of a Candidate for Election.

Name

Qualification or occupation

Address

being desirous of admission into the Royal Society of New South Wales, we, the undersigned members of the Society, propose and recommend him as a proper person to become a member thereof.

Dated this day of , 18 .

FROM PERSONAL KNOWLEDGE.	FROM GENERAL KNOWLEDGE.

Signature of candidate

Date received 18 .

Form No. 2.

ROYAL SOCIETY OF NEW SOUTH WALES.

The Society's Rooms,

Sir, Sydney, 18 .

I have the honor to inform you that you have this day been elected a member of the Royal Society of New South Wales, and I beg to forward to you a copy of the Fundamental Rules and By-laws of the Society, a printed copy of an obligation, a list of members, and a card announcing the dates of meeting during the present session.

According to the Regulations of the Society (*vide* Rule No. 6), you are required to pay your admission fee of one guinea, and annual subscription of one guinea for the current year, before admission. You are also requested to sign and return the enclosed form of obligation at your earliest convenience.

I have the honor to be,

Sir,

Your most obedient servant,

To Hon. Secretary.

Form No. 3.

ROYAL SOCIETY OF NEW SOUTH WALES.

I, the undersigned, do hereby engage that I will endeavour to promote the interests and welfare of the Royal Society of New South Wales, and to observe its Rules and By-laws as long as I shall remain a member thereof.

Signed,

Address

Date

Form No. 4.

ROYAL SOCIETY OF NEW SOUTH WALES.

The Society's Rooms,

Sir, Sydney, 18 .

I have the honor to inform you that your annual subscription of one guinea for the current year became due to the Royal Society on the 1st of May last.

It is requested that payment may be made by cheque or Post Office order drawn in favour of the Hon. Treasurer.

I have the honor to be,

Sir,

Your most obedient servant,

To Hon. Treasurer.

Form No. 5.

ROYAL SOCIETY OF NEW SOUTH WALES.

The Society's Rooms,

Sir, Sydney, 18 .

I am desired by the Royal Society of New South Wales to forward to you a copy of its Journal for the year 18 , as a donation to the library of your Society.

I am further requested to mention that the Society will be thankful to receive such of the very valuable publications issued by your Society as it may feel disposed to send.

I have the honor to be,

Sir,

Your most obedient servant,

Hon. Secretary.

Form No. 6.

ROYAL SOCIETY OF NEW SOUTH WALES.

The Society's Rooms,

Sir, Sydney, 18 .

On behalf of the Royal Society of New South Wales, I beg to acknowledge the receipt of and I am directed to convey to you the best thanks of the Society for your most valuable donation.

I have the honor to be,

Sir,

Your most obedient servant,

Hon. Secretary.

Form No. 7.

Balloting List for the Election of the Officers and Council.

ROYAL SOCIETY OF NEW SOUTH WALES.

May, 18 .

BALLOTING LIST for the election of the Officers and Council.

Present Council.	Names proposed as Members of the new Council.	
	Vice-Presidents.	
	Hon. Treasurer.	
	Hon. Secretaries.	
	Members of Council.	

If you wish to substitute any other name in place of that proposed, erase the printed name in the second column, and write opposite to it, in the third, that which you wish to substitute.

LIST OF THE MEMBERS

OF THE

Royal Society of New South Wales.

		street.
1877		Belfield, Algernon H., Eversleigh, Armidale.
1875		Belisario, John, M.D. Lyons' Terrace.
1876		Benbow, Clement A., 24, College-street.
1869	P 2	Bensusan, S. L., Exchange, Pitt-street.

Elected.		
1877		Bennett, George, Toowoomba, Queensland.
1877		Bennett, John, Victoria Theatre, Sydney.
1876		Bennett, Samuel, Little Coogee.
1877		Bladen, Thomas, Pyrmont.
1869		Bode, Rev. G. C., St. Leonards, North Shore.
1872		Bolding, H. I., P.M., Newcastle and Union Club.
1869		Boyd, Sprott, M.D. *Edin.*, M.R.C.S. *Eng.*, Lyons' Terrace.
1874		Bowen, George M. C., Keston, Kirribilli Point, North Shore.
1858		Bradridge, Thomas H., Town Hall, George-street.
1876		Brady, Andrew John, Lic. K. & Q. Coll. Phys. *Irel.*, Lic. R. Coll. Sur. *Irel.*, Sydney Infirmary.
1871	P 1	Brazier, John, C.M.Z.S., 11, Windmill-street.
1868		Brereton, John Le Gay, M.D. *St. Andrew's*, L.R.C.S. *Edin.*, Macquarie-street.
1874		Brewster, John, George-street.
1876		Bristowe, E. H. C., 435, Crown-street, Sydney.
1876		Brodribb, W. A., F.R.G.S., Double Bay.
1876		Brown, Henry Joseph, Newcastle.
1875		Brown, Thomas, Eskbank, Bowenfels, and Australian Club.
1877		Bundock, W. C., 165, Victoria-street.
1876		Burn, James Henry, 69, Hunter-street.
1875		Busby, The Hon. William, M.L.C., Redleaf, South Head Road, Woollahra.
1875		Burton, Edmund, Land Titles Office, Elizabeth-street North.
1877		Burnell, Arthur, Survey Office.
1876		Cadell, Alfred, Vegetable Creek, New England.
1876		Cadell, Thomas, Wotonga, East St. Leonards.
1876		Campbell, Allan, L.R.C.P., *Glasgow*, Yass.
1876		Campbell, The Hon. Alexander, M.L.C., Woollahra.
1868		Campbell, The Hon. Charles, M.L.C., Pine Villa, Newtown.
1872		Campbell, The Hon. John, M.L.C., Campbell's Wharf, Lower George-street.
1870		Cane, Alfred, Stanley-street.
1876		Cape, Alfred J., Torfrida, Elizabeth Bay.
1876		Chandler, Alfred, 185 Pitt-street.
1876		Christie, Wm., L.S., Hawthorn Lodge, Glen Innes.
1850	P 18	†Clarke, Rev. W. B., M.A. *Cantab.*, F.R.S., F.G.S., C.M.Z.S., F.R.G.S., Mem. Geol. Soc. France, Corres. Imp. Roy. Geol. Inst. Austria, Hon. Mem. N.Z. Inst. Cor. Mem. Roy. Soc. Tasmania, Fellow of St. Paul's College, *Vice-President*, Branthwaite, St. Leonards, North Shore.
1877		Clarke, William, E. S. & A. C. Bank, Pitt-street.
1874		Clay, William French, M.A., *Cantab.*, M.D *Syd.*, M.R.C.S. *Eng.*, Fellow of St. Paul's Col., North Shore.
1876		Clune, Michael Joseph, M.A., Lic. K & Q. Coll. Phys. *Irel.*, Lic. R. Coll. Sur. *Irel.*, 4, Hyde Park Terrace.
1876		Codrington, John Fredk., M.R.C.S., E.; Lic. R C. Phys., L.; Lic. R C. Phys., *Edin.*, Orange.
1876		Colyer, John Ussher Cox, A.S.N. Company, Sydney.
1856		Comrie, James, Northfield, Kurrajong Heights.
1876		Conder, Wm., Survey Office, Sydney.
1874		Coombes, Edward, Bathurst.
1859	P 1	Cox, James, M.D. *Edin.* C.M.Z.S., F.L.S., Hunter-street.

Elected.		
1865	P 2	Cracknell, E. C., Superintendent of Telegraphs, Telegraph Office, George-street.
1869		Creed, J. Mildred, M.R.C.S. *Eng.*, Scone.
1870		Croudace, Thomas, Lambton.
1877		Cunningham, Andrew, Lanyon, Queanbeyan.
1873		Daintrey, Edwin, Æolia, Randwick.
1876		Dalgarno, John V., Telegraph Office, George-street.
1876		Dansey, George Frederick, M.R.C.S., London, York and Margaret Streets, Wynyard Square.
1874		Dansey, John, M.R.C.S. *Eng.*, Wynyard Square.
1875		Dangar, Frederick H., Greenknowes, Darlinghurst.
1876		Darley, Cecil West, Newcastle.
1877		Darley, F. M., M.A., Union Club, Sydney.
1876		Davidson, L. Gordon, M.D., M.C., *Aberdeen*, Goulburn.
1877		Deck, John Feild, M.D., 251, Macquarie-street.
1856		Deffell, George H., Bayfield, Woolwich Road, Hunter's Hill.
1869		De Lissa, Alfred, Pitt-street.
1875		De Salis, The Hon. Leopold Fane, M.L.C., Cuppercumbalong, Lanyon.
1875		De Salis, L. W., junr., Strathmore, Bowen, Queensland.
1873		Dibbs, George R., M.P., 131, Pitt-street.
1876		Dight, Arthur, Richmond.
1876		Dixon Douglas, Australian Club.
1875	P 2	Dixon, W. A., F.C.S., Hunter-street.
1876		Docker, Ernest, M.A. *Sydn.*, 134, Burton-street.
1876		Douglas James, L.R.C.S. *Edin.*, Hope Terrace, Glebe Road.
1876		Drake, William Hedley, Commercial Bank, Inverell.
1873		Du Faur, Eccleston, F.R.G.S., Rialto Terrace.
1876		Eales, John, Duckenfield Park, Morpeth.
1876		Egan Myles, M.R.C.S., *Eng.*, 2, Hyde Park Terrace, Liverpool-street.
1874		Eichler, Charles F., M.D., *Heidelberg*, M.R.C.S., *Eng.*, Bridge-street.
1876		Eldred, W. H., 119, Castlereagh-street.
1876		Evans, George, Como, Darling Point.
1876		Evans, Owen Spencer, M.R.C.S., *Eng.*, Darling-street, Balmain.
1877		Fache, Charles James, Cleveland House, Redfern.
1877		Fairfax, Edward R., 177, Macquarie-street.
1868		†Fairfax, James R., *Herald* Office, Hunter-street.
1872		Farnell, J. Squire, M.P., Ryde.
1874		Fischer, Carl F., M.D., F.L.S., Soc. Zool. Bot. Vindob. Socius., 251, Macquarie-street.
1876		Fisher, Chas. Marshall, 132, Pitt-street.
1876		Fitzgerald, R. D., F.L.S., Surveyor General's Office.
1856		Flavelle, John, George-street.
1876		Forde, W., Carlton Terrace, Wynyard Square.
1863		Fortescue, G., M.B. *Lond.*, F.R.C.S., F.L.S., Lyons' Terrace.

Elected.		
1877		Fraser, A. C., 235, Albion-street.
1875		Frazer, Hon. John, M.L.C., Quirang, Woollahra.
1876		Frean Richard, M.R.C.S. *Eng.*, Sydney Infirmary.
1876		Freehill, Bernard Austin, 130, Elizabeth-street.
1876		Firth, Rev. Frank, Wesleyan Parsonage, Waverley.
1877		Garnsey, Rev. C. F., St. James's Parsonage, Sydney.
1868	P 1	Garran, Andrew, LL.D. *Syd.*, *Herald* Office, Hunter-street.
1877		Garvan, J. P., 130, Elizabeth-street, Sydney,
1876		George, W. R, 172, Castlereagh-street.
1876		Gilchrist, W. O., Elizabeth Bay.
1875		Gilliat, Henry Alfred, Australian Club.
1876		Gillman, Thomas Henry, B.A., C.M., M.D., Queen's Univ. *Irel.*, Mast. Surg. Queen's Univ. *Irel.*, 20, College-street.
1876		Gipps, F. B., 134, Pitt-street.
1859		Goodlet, John H., George-street.
1876		Goode, George, M.B. Univ. *Dub.*, B.A., M.C.L., Eversfield House, Camden.
1876		Graham, Hon. Wm., M.L.C., Stratheam House, Waverley.
1873		Greaves, W. A. B., Armidale.
1877		Griffiths, Neville, The Domain, Sydney.
1875		Grundy, F. H., 183, Pitt-street.
1877		Gurney, T. T., M.A., Professor of Mathematics, University of Sydney.
1864		Hale, Thomas, Gresham-street.
1874		Hardy, J., Hunter-street.
1877		Hargrave, Lawrence, 94, Upper William-street.
1877		Harrison, L. M., Moira, Burwood.
1877		Hawkins, H. S., M.A., Balmain.
1874		Hay, The Hon. John, M.A., *Glasgow*, M.L.C., President of the Legislative Council, Rose Bay, Woollahra.
1876		Heaton, J. H., *Town and Country* Office, Pitt-street.
1875		Helsham, Douglass, York's Terrace, Glebe.
1877		Henry, James, 754, George-street.
1876		Heron, Henry, 4, Rialto Terrace, William-street South.
1859		‡Hill, Edward S., C.M.Z.S., Rose Bay, Woollahra.
1877		Hindson, Lawrence, Careening Cove, North Shore.
1876	P 1	Hirst, Geo. D., 379, George-street.
1868		Holt, The Hon. Thomas, M.L.C., The Warren, near Sydney.
1876		Holroyd, Arther Todd, M.B. *Cantab.*, M.D. *Edin.*, F.L.S., F.Z.S., F.R.G.S., Master-in-Equity, Sherwood Scrubs, Parramatta.
1870	P 1	Horton, Rev. Thomas, Ina Terrace, Woollahra.
1877		Hume, J. K., Cooma Cottage, Yass.
1876		Icely, Thos. R., Carcoar.
1877		Innes, Sir J. George L., Knt., Darlinghurst.

Elected.		
1876		Jackson, Henry William, L.R.C.S. *Edin.*, Lic. R. Phys., *Edin.*, 130, Phillip-street.
1876		Jenkins, Richard Lewis, M.R.C.S., Nepean Towers, Douglass Park.
1874		Jennings, P. A., Edgecliffe Road, Woollahra.
1877		Jennings, W. E., B.A., Mining Department, Sydney.
1876		Jones, James Aberdeen, Lic. R.C. Phys,. *Edin.*, Booth-street, Balmain.
1876		Jones, Richard Theophilus, M.D. *Sydn.*, L.R.C.P. *Edin.*, Ashfield.
1867		†Jones, P. Sydney, M.D. *Lond.*, F.R.C.S. *Eng.*, College-street.
1877		Jones, Edward Lloyd, 345, George-street, Sydney.
1874		Jones, James, Bathurst-street.
1877		Jones, Griffith Evan Russell, B.A., *Syd.*, 382, Crown-street, Surry Hills.
1863		Josephson, Joshua Frey, F.G.S., District Court Judge, Enmore Road, Newtown.
1876		Josephson, J. P., 253, Macquarie-street North.
1873		Keele, Thos. Wm., Harbours and Rivers Department, Phillip-street.
1877		Keep, John, Broughton, Leichhardt.
1873		Kennedy, Hugh, B.A. *Oxon.* Registrar of the Sydney University.
1874		King, Philip G., William-street, Double Bay.
1877		Kinloch, John, M.A., Hyde Park, Sydney.
1877		Knox, Edward, jun., Fiona, Double Bay.
1874		Knox, George, M.A., *Cantab.*, King-street.
1875		Knox, Edward, 24, Bridge-street.
1877		Kopsch, G., 8 Bridge-street.
1867	P 3	Lang, Rev. John Dunmore, D.D., M.A. *Glasgow*, Jamison-street.
1876		Langley, W.E., *Herald* Office, Sydney.
1874	P 1	Latta, G. J., O'Connell-street.
1876		Laure, Louis Thos., M.D. Surg. Univ. *Paris*, 131, Castlereagh-street.
1859	P 5	†Leibius, Adolph, Ph. D. *Heidelberg*, Senior Assayer to the Sydney Branch of the Royal Mint, *Hon. Secretary*.
1874		Lenehan, Henry Alfred, Computer,, Sydney Observatory.
1872	P 9	†Liversidge, Archibald, F.C.S.; F.G.S.; F.L.S.; F.R.G.S.; Assoc. R. S. Mines, *Lond.;* Mem. Phy. Soc. London; Mem. Mineralogical Soc. Gt. Brit. and Irel.; Cor. Mem. Roy. Soc. Tas.; Cor. Mem. Senckenberg Institute, Frankfurt; Cor. Mem. Soc. d'Acclimat. Mauritius; Hon. F. R. Hist. Soc. Lond.; Professor of Geology and Mineralogy in the University of Sydney, *Hon. Secretary*, Union Club.
1875		Living, John, Marsaloo, North Shore.
1874		Lloyd, George Alfred, M.P., F.R.G.S., O'Connell-street.
1876		Lord, The Hon. Francis, M.L.C., North Shore.
1877		Lord, George Lee, Woolloomooloo.
1876		Lyons, W., M.R.C.S., *Eng.*, Wollongong.

Elected.		
1870		Macafee, Arthur H. C., York-street.
1876		M'Carthy, W. F., Deepdeen, Glenmore Road.
1876		M'Culloch, A. H., jun., 165, Pitt-street.
1874		M'Cutcheon, John Warner, Assayer to the Sydney Branch of the Royal Mint.
1859		MacDonnell, William, George-street.
1868		MacDonnell, William J., F.R.A.S., George-street.
1877		MacDonnell, Samuel, 326, George-street, Sydney.
1876		M'Guire, W. H., Telegraph Office, George-street.
1872		Mackenzie, John, F.G.S., Examiner of Coal Fields, Newcastle.
1874		Mackenzie, W. F., M.R.C.S., *Eng.*, Lyons' Terrace.
1876		Mackenzie, Rev. P. F., Paddington.
1876		Mackellar, Chas. Kinnard, M.B., C.M., *Glas.*, Lyons' Terrace.
1876		M'Kay, Dr., Church Hill.
1876		Maclaurin, Henry Norman, M.A., M.D. Univ., *Edin.*, Lic. R. Coll. Sur. *Edin.*, 187, Macquarie-street.
1873		Makin, G. E., Berrima.
1877		Mann, John, Neutral Bay.
1873	P 4	Manning, James, Milsom's Point, North Shore.
1876		Manning. Frederick Norton, M.D. Univ. *St. And.*, M.R.C.S., *Eng.*, Lic. Soc. Apoth. *Lond.*, Gladesville.
1869		Mansfield, G. A., Pitt-street.
1872		Marsden, The Right Rev. Dr., Bishop of Bathurst, Bathurst.
1876		Marsh, J. M., Edgecliff Road, Woollahra.
1876		Marshall, George, M.D. Univ. *Glas.*, Lic. R. Coll. S. *Edin.*, Lyons' Terrace.
1876		Martin, Rev. George, Victoria Terrace, Miller's Point.
1876		Martin, John, Addington, Ryde.
1875		Mathews, R. H., Mundooran.
1877		Merriman, James, Mayor of Sydney.
1868		Metcalfe, Michael, Bridge-street.
1873		Milford, F., M.D., *Heidelberg*, M.R.C.S. *Eng.*, College-street.
1876		Milford, S. F. F., Lands Office.
1876		Millard, Rev. Henry Shaw, Newcastle Grammar School.
1875		Moir, James, Margaret-street.
1875		Montefiore, E. L., Macleay-street.
1876		Montefiore, George B., F.G.S., 5, Gresham-street.
1856	P 2	†Moore, Charles, F.L.S., Director of the Botanic Gardens, Botanic Gardens.
		Morehead, R. A. A., 30, O'Connell-street.
1872		Morgan. Cosby William, M.D. *Brussels*, L.R.C.P. *Lond.*, 137, Castlereagh-street.
1876		Morgan, Allan Bradley, M.R.C.S. *Eng.*, Lic. Mid. Lic. R. Coll. Phys. *Edin.*, Ashenhurst, Burwood.
1876		Morgan, T. C., 137, Castlereagh-street.
1865	P 1	Morrell, G. A., C.E., Department of Works, Phillip-street.
1877		Morris, William, L.F.P. and S. *Glas.*, Wynyard Square, Sydney.
1877		‡Mullens, Josiah, F.R.G.S., 34, Hunter-street.
1865		Murnin, M. E., Exchange, Bridge-street.
1876		Murray, W. G., 52, Pitt-street.
1876		Myles, Chas. Henry, Wymela, Burwood.
1873		Neill, William, City Bank, Pitt-street.
1874		Neill, A. L. P., City Bank, Pitt-street.

Elected.		
1876		Neild, John Cash, M.D. & C.D., *Berlin*, M.R.C.S. *Eng.*, Lic. Soc. Apoth. *Lond.*, Elzabeth-street, Sydney.
1874		Nicol, D., Burwood.
1876		Nilson, Aroid, Department of Mines.
1873		Norton, James, Elizabeth-street.
1875		Nott, Thomas, M.D. *Aberdeen*, M.R.C.S. *Eng.*, Ocean-street, Woollahra.
1877		Olley, Rev. Jacob, Hunter's Hill.
1875		O'Reilly, W. W. J., M.D., M.C., Q. Univ. *Irel.*, M.R.C.S., *Eng.*, Liverpool-street.
1875		Owen, The Hon. Robert, M.L.C., 88, Elizabeth-street.
1875		Palmer, J. H., Legislative Assembly.
1876		Parbury, Chas., Union Club.
1876		Parrott, Thomas S., Ashfield.
1861		Paterson, Hugh, Macquarie-street.
1877		Paterson, James A., Union Bank, Pitt-street.
1877		Pedley, Percival R., 1 Carlton Terrace, Wynyard Square.
1872		Pendergast, Robert, Hay-street.
1877		Perkins, Henry A., Ocean-street, Woollahra.
1875		Phillip, H., Pacific Insurance Company.
1876		Pickburn Thomas, M.D., *Aberdeen*, Ch. M., M.R.C.S., *Eng.*, 40, College-street.
1877		Pile, George, 62, Margaret-street, Sydney.
1862		Prince, Henry, George-street.
1876		Quaife, Fredk. Harrison, M.D., Mast. Surg. Univ. *Glas.*, Piper-street, Woollahra.
1876		Quirk, Rev. Dr. J. A., O.S.B., LL.D., *Syd.*, Lyndhurst College.
1876		Quodling, W. H., Burwood.
1865	P 1	‡Ramsay, Edward, F.L.S., Curator of the Australian Museum, College-street.
1876		‡Ratte, F., Noumea, New Caledonia.
1874		Read, Reginald Bligh, M.R.C.S., *Eng.*, Randwick.
1877		Read, Richard, M.D., Singleton.
1868		Reading, E., Mem. Odont. Soc. *Lond.*, Castlereagh-street.
1876		Reece, J. D., Surveyor General's Office.
1870		Renwick, Arthur, M.D. *Edin.*, B.A., *Sydn.*, F.R.C.S.E., 295, Elizabeth-street.
1856		Roberts, J., George-street.
1868	P 3	Roberts, Alfred, M.R.C.S. *Eng.*, Hon. Mem. Zool. and Bot. Soc. Vienna, Bridge-street.
1876		Roberts, Rev. W. H., B.A., *Dublin*, St. Paul's College, Newtown.
1871		Robertson, Thomas, M.P., Pitt-street North.
1872		Robinson, His Excellency Sir Hercules, G.C.M.G., Governor of New South Wales, Government House.

Elected.		
1873		Rogers, Rev. Edward, Rural Dean, Fort-street.
1856	P 5	†Rolleston, Christopher, Auditor General, Castlereagh-street.
1865		Ross, J. Grafton, 24, Bridge-street.
1876		Rowling, Dr., Mudgee.
1864	P 12	†Russell, Henry C., B.A., *Syd.*, F.R.A.S., F.M.S., Hon. Mem. S. Aust. Inst., Government Astronomer, Sydney Observatory, *Vice-President.*
1875		Sahl, Charles L., German Consul, Consulate of the German Empire, Wynyard Square.
1876		Saliniere, Rev. E. M., Glebe.
1876		Samuel, The Hon. Saul, C.M.G., M.L.C., Gresham-street.
1876		Schuette, Rudolf, M.D., Univ. *Göttingen,* Lic. Soc. Apoth. *Lond.*, 10, College-street.
1856	P 1	†‡Scott, Rev. William, M.A. *Cantab.*, Hon. Mem. Roy. Soc. Vic., Warden of St. Paul's College, *Hon. Treasurer*, St. Paul's College, Newtown.
1876		Scott, A.W., M.A. *Cantab.*, Ferndale, South Head Road.
1876		Sedgwick, Wm. Gillett, M.R.C.S., *Eng.*, Newtown.
1877		Selfe, Norman, C.E., Rockleigh, Balmain.
1876		Sharp, James Burleigh, J.P., Clifton Wood, Yass.
1876		Sharp, Henry, Green Hills, Adelong.
1875		Sheppard, Rev. G., Elizabeth-street.
1876		Shields, John, M.R.C.S., *Ed.*, Bega.
1875		Slade, G.P., Wheatley, North Shore.
1877		Slattery, Thomas, Manly Beach.
1872		Sleep, John S., 139, Pitt-street.
1877		Sloper, Fredk. Evans, 360, Liverpool-street.
1852	P4	†Smith, John, The Hon., C.M.G., M.D., LL.D., *Aberdeen*, M.L.C., F.C.S., Hon. Mem. Roy. Soc. Vic., Professor of Physics and Chemistry in the University of Sydney, 193, Macquarie-street.
1875		Smith, Robt., B.A., *Syd.*, Solicitor, Bridge-street.
1874		Smith, John M'Garvie, 404, George-street.
1876		Smith, R. S., Surveyor General's Office.
1876		Southey, H. E., Oaklands, Mittagong.
1876		Stackhouse, Thos., Commander R.N., Australian Club.
1872	P1	Stephen, George Milner, B.A., F.G.S., Mem. Geol. Soc. of Germany; Cor. Mem. Nat. Hist. Soc., Dresden; F.R.G.S. of Cornwall; Five Dock.
1857		Stephens, William John, M.A. *Oxon.*, 233, Darlinghurst Road.
1876		Stopps, Arthur J., Surveyor General's Office.
1876		Strong, Wm. Edmund, M.D., *Aberdeen*, M.R.C.S., *Eng.*, Liverpool.
1874		Stuart, The Hon. Alexander, M.P., Colonial Treasurer, Clunes, Cambridge-street, South Kingston, Petersham.
1876		Stuart, Clarendon, Upper William Street South.
1876		Suttor, Wm. Henry, J.P., Cangoura, Bathurst.
1874		Taylor, Chas., M.D. *Syd.*, M.R.C.S., *Eng.*, Parramatta.
1876		Tayler, William George, F.R.C.S., *Lond.*, 219, Pitt-street.

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Elected.		
1862	P 5	Tebbutt, John, F.R.A.S., Observatory, Windsor.
1870	P 1	Thompson, H. A., O'Connell-street.
1875		Thompson, Joseph, Potts' Point.
1877		Thompson, Thos. James, Pitt-street, Sydney.
1876		Thomas, H. Arding, Narellan.
1876		Thomas, Wm. Smith, M.R.C.S., *Eng.*, Wollongong.
1876		Tibbits, Walter Hugh, Dubbo.
1876		Toohey, J. T., Melrose Cottage, Cleveland-street.
1873		Trebeck, Prosper N., George-street.
1876		Trouton, F. H., A.S.N. Company's Offices, Sydney.
1877		Tucker, G. A., Superintendent, Bay View Asylum, Cook's River.
1868		Tucker, William, Clifton, North Shore.
1875		Tulloh, W. H., Margaret-street.
1875		Turner, G., 3 Fitzroy Terrace, Pitt-street, Redfern.
1874		Vessey, Leonard A., Survey Office.
1876		Voss, Houlton H., Union Club.
1867		Walker, Philip B., Telegraph Office, George-street.
1870		Wallis, William, Moncur Lodge, Potts' Point.
1867		Ward, R. D., M.R.C.S. *Eng.*, North Shore.
1877		Warren, William Edward, M.D., M.R.C.S., 26, College-street, Sydney.
1876		Waterhouse, J. M.A. *Syd.*, Newington College, Parramatta.
1876		Watkins, John Leo, B.A. *Cantab.*, M.A. *Syd.*, Randwick.
1876		Watson, C. Russell, M.R.C.S., *Eng.*, Camden Terrace, Newtown.
1877		Watt, Alfred Joseph, Ashfield, Parramatta Road.
1859		Watt, Charles, New Pitt-street.
1874		Watt, John B., The Hon., M.L.C., 104, Macleay-street.
1876		Waugh, Isaac, M.B., M.C., *T.C.D.*, Parramatta.
1876		Webster, A. S., Union Club.
1867		Weigall, Albert Bythesea, B.A. *Oxon.*, M.A. *Syd.*, Head Master of the Sydney Grammar School, College-street.
1877		Weston, W. J., Union Club.
1874		White, Rev. James S., M.A., LL.D., *Syd.*, Gowrie, Singleton.
1875		White, Hon. James, M.L.C., Cranbrook, Double Bay.
1877		White, Rev. W. Moore, LL.D., Arthursleigh Terrace, Elizabeth-street.
1876		Wilson, F. H., Newtown.
1876		Windeyer, Hon. W. C., M.A., *Syd.*, M.L.A., King-street.
1876		Wise, George Foster, Immigration Office, Hyde Park.
1874		Wilkinson, C. S., Government Geologist, Department of Mines.
1876		Wilkinson, Henry Toller, Department of Mines.
1862		Williams, J. P., New Pitt-street.
1876		Williams, Percy, Treasury.
1873		Wood, Harrie, Under Secretary for Mines, Department of Mines.
1874		Woodgate, E., Parramatta.
1877		Woods, T. A. Tenison-, Phillip-street, Sydney.
1876		Woolrych, F. B. W., 138, Castlereagh-street.
1872		Wright, Horatio, G. A., M.R.C.S., *Eng.*, Wynyard Square.

Honorary Members.

Elected, August, 1875.

Agnew, Dr., Hon. Secretary, Royal Society of Tasmania, Hobart Town.

Barlee, The Hon. F., late Colonial Secretary of Western Australia.

Bernays, Lewis A., F.L.S., Vice-President of the Queensland Acclimatization Society, Brisbane.

Ellery, Robert F., F.R.S., F.R.A.S., Government Astronomer of Victoria, Melbourne.

Gregory, Augustus Charles, F.R.G.S., Surveyor General of Queensland, Brisbane.

Haast, Dr. Julius von, Ph. D., F.R.S., F.G.S., Government Geologist and Director of the Canterbury Museum, New Zealand.

Hector, James, C.M.G., M.D., F.R.S., Director of the Colonial Museum and Geological Survey of New Zealand, Wellington.

M'Coy, Frederick, F.G.S., Hon. F.C.P.S., C.M.Z.S., Professor of Natural Science in the Melbourne University, Government Palæontologist, and Director of the National Museum, Melbourne.

Müller, Baron Ferdinand von, C.M.G., M.D., Ph. D., F.R.S., F.L.S., Government Botanist, Melbourne.

Schomburgh, Dr., Director of the Botanic Gardens, Adelaide, South Australia.

Waterhouse, F. G., F.G.S., C.M.Z.S., Curator of the Museum, Adelaide, South Australia.

Woods, Rev. Julian E. Tenison, F.G.S., F.R.G.S., Hon. Mem. Roy. Soc., Vic., Hobart Town, Tasmania.

Elected, 6 *December*, 1876.

Cockle, His Honor Sir James, Chief Justice, M.A., F.R.S., Brisbane, Queensland.

De Koninck, Prof., M.D., Liège, Belgium.

Obituary, 1877.

Elected.

1870. Allen, The Hon. George, M.L.C., Toxteth Park, Glebe.

1868. Fairfax, The Hon. John, M.L.C., *Herald* Office, Hunter-street.

1874. Pedley, Frederick, Wynyard-square.

ANNIVERSARY ADDRESS.

By H. C. Russell, B.A., F.R.A.S., &c., Vice-President.

[*Delivered before the Royal Society of N.S.W., 2 May,* 1877.]

Gentlemen,

At the commencement of last session it was your pleasure to elect me one of your Vice-presidents, and in so doing to lay upon me the duty of giving the opening address this session. I wish your choice had fallen on some one with more leisure than myself, or that we might, as in years past, have had the pleasure of listening to our honored and senior Vice-president, whose unceasing labours on behalf of our Society have earned for him such a high place in our esteem.

Fifty-six years have passed since a few (ten) earnest workers met together in Sydney, and formed the first Scientific Society in Australia. We are proud that we can trace the origin of our Society to that early effort made to plant science on a new soil; and although there have been periods of depression—" droughts" in our scientific world during which no progress was made--yet the Report you have just heard contains ample proof that the young Society was planted on congenial soil.

You have heard, then, what we have done during the past year, and I need not dwell upon it, except on one or two points, for which I ask your forbearance.

First, however, allow me to congratulate you upon our flourishing condition.

With 132 members added to our number during the year, with seven working sections formed, with 1,000 books added to our library, besides furniture and instruments purchased for our use,

with a volume showing our year's work larger than any which has preceded it, with friendly exchange relations established with no less than 107 kindred Societies scattered over all parts of the world, with a growing spirit of work amongst our members, and with a fair prospect that a liberal Government will help us to carry out our purposes, we certainly have good reason to congratulate ourselves on the year's progress.

The following list of papers read does not include those read to the Sections; but the number (15) bears favourable comparison with the number (10) read the previous year:—

1. Anniversary Address. By the Rev. W. B. Clarke, M.A., F.R.S.
2. Notes on some remarkable Errors shown by Thermometers. By H. C. Russell, B.A., F.R.A.S.
3. On the Origin and Migration of the Polynesian Nations. By Rev. Dr. Lang.
4. On the Deep Oceanic Depression off Moreton Bay. By Rev. W. B. Clarke, M.A., F.R.S.
5. Some Notes on Jupiter during his Opposition of 1876. By Mr. G. D. Hirst.
6. On the Genus Ctenodus. By Mr. W. J. Barkas, M.R.C.S.E.
7. Part 2 of above paper, being Microscopic Structure of Mandibular and Palatal Teeth of Ctenodus.
8. Part 3 of above, Vomerine Teeth of Ctenodus.
9. Part 4 of above, on the Dentary Articular and Pterygo-palatine Bones of Ctenodus.
10. On the formation of Moss Gold and Silver. By Archibald Liversidge, Professor of Geology and Mineralogy in the University of Sydney.
11. Recent Copper-extracting Processes. By Mr. S. L. Bensusan.
12. Meteorological Periodicity. By H. C. Russell, B.A., F.R.A.S.
13. Effects of Forest Vegetation on Climate. By Rev. W. B. Clarke, M.A., F.R.S.
14. Fossiliferous Siliceous Deposit from Richmond River, New South Wales. By Archibald Liversidge, Professor of Geology and Mineralogy in the University of Sydney.
15. On a remarkable example of Contorted Slate. By Archibald Liversidge, Professor of Geology and Mineralogy in the University of Sydney.

In addition to the above, four papers were read in the Astronomical Section, three in the Section for Chemistry and Mineralogy,

five in the Microscopical Section, one to Fine Arts Section, several read to the Medical Section (number not given in Report), two to the Sanitary Section; besides which, a great deal of useful work was done in the Sections, and several of them formed a basis on which they will be able to increase their usefulness during this session.

The work done by our Sections was therefore considerable, and will appear still more so, if it is borne in mind that, owing to the time lost in preliminary arrangements, they could not begin until July.

When it was announced at our last Annual Meeting that Sections would be formed, some of the most sanguine amongst us thought that not more than three or four could be formed on a working basis; and I confess that I was not a little surprised when seven out of the nine proposed were formed. Surely no better proof could be desired, that the wish to be at work was increasing amongst us. And the progress made last session justifies the hope that, during the one on which we are entering, much more will be accomplished. There are amongst us, no doubt, many workers who have not the leisure required to prepare such a formal paper as the Royal Society requires, who will find in the Sections ample opportunity for bringing their work forward. And, if I may venture to make a suggestion on this subject, it is that they should devote themselves specially to such facts and phenomena as are peculiar to Australia, for by so doing our Journal will become of very great value in the estimation of those to whom we send it in exchange for the valuable works which they publish.

The Report has justly reminded you of the obligation we are under owing to the liberality of our Government in printing our Journal; but I cannot let the allusion pass without calling your attention to the difficulty there is in getting much of the technical matter we publish through the Press, and the obligation we owe both to Mr. T. Richards, Government Printer, and to Mr. C. Potter, Acting Government Printer, for their uniform courtesy and attention to our wants while getting the Journal through the Press.

Another matter which should not be passed over with so short a notice as is given to it in our Council's Report, is the establishment of exchange relations with no less than 107 other and kindred Societies scattered over the world. By this means we have, in return for 579 volumes sent out (our own and others given us for distribution), secured at least 1,000 new works for our library, very many of them valuable ones, which could only have been obtained for use in the Colony in exchange for works of a kindred Society like ours. This alone is no small matter to record for the past year, and it reminds me of something I wished to say. You all know how our Rules set forth that the "object of this Society is to receive original papers on scientific subjects, art, literature, and philosophy; and especially such subjects as tend to develop the resources of Australia, and illustrate its natural history and productions"; and you also know how, in a humble way, we have steadily kept to our purpose, but by adding to it this year the distribution of our own and other publications of a like character, partly for the return we knew we should get, and partly with the object of spreading knowledge, we have, so far as our means permitted, taken in this Colony the position held by the Smithsonian Institution in America. That institution had, as you are aware, an origin very different from ours, it is a monument to the love of knowledge and munificence of an Englishman named "Smithson," who, on condition that the money was spent for the "Increase and diffusion of knowledge among men," devoted his fortune (about £100,000) to found it. Right nobly the work is carried on by the Regents or Council of the institution, in publishing new works, and in sending them, together with all the scientific books they can get, the world over. Sustained by ample funds from the endowment, they can act as their love of science dictates, while we who have only our subscriptions to work upon, are following their example as far as we can. It is a laudable position for us to aspire to; and I hope that as our "Smithson" has not yet appeared, our Government will help us to do this work, which is for the public good, until he does.

The Report also alludes to two other matters which I should like to bring more particularly under your notice. One is that we have devoted a considerable sum of money to the purchase of scientific periodicals for our library, and although it has helped materially to reduce our Treasurer's balance, it is a good investment.

The other is the number of valuable donations that have been received from our members. Their names as donors have already been laid before you at the monthly meetings, and will be found recorded in our annual Journal, now on the table. I would like to read them over, but the list is too long. I cannot, however, refrain from calling your attention to one fact, that the spirit amongst us which these donations evince is a most satisfactory one to recognize. It is the source from which kindred Societies in England and elsewhere derive so many valuable books and instruments. And I have no doubt that when it becomes known that the donors' names are permanently recorded as benefactors of the Society, and that such gifts in the hands of the Librarian become extremely valuable to the members, we shall have many more to record. From the three sources I have named, we are collecting a library, which as many of you are aware, is rapidly filling our small council room.

I hope that I have not been tedious in making these remarks. I have done so because I think we have arrived at a most important period of our history, and much of our future progress will depend upon the course we now adopt. For we have grown to be a large Scientific Society; we have divided ourselves into Sections, and find many willing to work—more even than we expected, and we have no elbow-room in which to accommodate them. If this continues, it will be found one of the most effective things in checking the usefulness of the members, who at least expect a comfortable place to work in. Indeed, the Society has always wanted house-room, and it may be said, perhaps to its credit, that it has heretofore thought more of its work than its home. And I hope it will continue to do

so. But I am sure I am only speaking the conviction of the majority of our members when I say that the time has arrived when we *ought* to have, when we *must have*, a home of our own. Every kindred Society that I know of is provided with a home at Government expense, both here and in other places. In England, the Royal and other Societies are provided with splendid rooms in Burlington House, which must have cost the Government upwards of £100,000. They receive also annual grants from the Government, and this year the Royal Society's share is £5,000, a clear proof of the value of such an institution in the community. Coming nearer home, the Royal Society in Victoria received from the Government a piece of land in Melbourne, and £2,000 towards their building, together with an annual grant of £200. In Tasmania the Royal Society is provided by the Government with fine rooms, and has an annual grant of money, and so in other places; while the Royal Society of Sydney has never received any assistance from Government except the printing of our Journal since 1873. This is not a fair position for us to be in; and I am convinced that if we rightly represent the matter, we shall obtain the assistance we need to enable us to extend our usefulness. I will not here discuss the question of how this should be done; but I think it is a proper object to place in the hands of a committee of the members.

With one remark bearing upon the subject I will leave it. The question may be asked, does it pay to foster science? We have not far to look in the experience of other countries for an answer, and their experience points unmistakeably to the fact that science is the mainspring of advancement in arts and manufactures. Let science keep in the back-ground, and art at once becomes a machine, reproducing the same thing age after age, with a gradual deterioration proportionate to the wear and tear, as we see in Eastern countries; but let science take its legitimate place, let instruction and means be given to the thoughtful workers in its fields, and it is soon found to be but an easy step from pure science to pure art.

It is not many years since England was the workshop of the world; and Germany, like some other nations, looked on, wishing to share the profits, but unable to do so. Her rulers wisely thought that the reason was a want of education in the physical sciences, and they made her schools of chemistry the best in Europe. Students flocked there—even from other countries—and they came away full of the spirit of research, and ennobled by daily contact with her renowned professors. What is the result? Forty years since, industry in the arts could scarcely be said to exist in Germany. Now England has lost one of her best customers and found a rival instead; and not to mention other articles, in the newest European industry, that of the manufacture of dyes. Germany, last year, made more than all the rest of Europe, England and France included.

So much for the culture of science, and it affords a lesson which England has not been slow to profit by, for she is now devoting money freely to science culture. And if we are to keep pace with the world we must do likewise. As one of the leading men of the day has recently said—"There can be no doubt that, whether science be looked upon as a means of culture or as a means of commercial progress, it is both our duty and our interest to promote it."

Turning now to the scientific progress made during the year, I feel that it is hopeless to try to condense within the limits of this address what would fill a goodly volume; and the field is so large that I fear even to enter it lest I should not get out before your patience was exhausted, especially as we have another important paper to read to-night. I will therefore try and select only a few facts from the great multitude.

In spectrum analysis no *great* discovery has been made, but much has been done in its various branches. Messrs. Roscoe and Schuster's valuable investigations into the absorption of bands of potassium and sodium, together with Lockyer's work on the varying absorptive powers of metallic and metalloidal vapours under different temperatures, and especially with regard to calcium, which gives two distinct spectra—are most valuable contributions to science.

Mr. Christie, using the large spectroscope of the Greenwich Observatory, has confirmed Dr. Huggins's marvellous discovery of the proper motion of stars, but he has not been able, any more than Dr. Huggins, to find proofs of motion in the nebulæ. No doubt this is owing to the inherent difficulty of getting exact measures of the bright lines of faint spectra. Dr. Huggins has this year made another advance in the examination of star spectra, and has succeeded in so improving his apparatus that a star can be kept on the slit of the spectroscope until a photograph is taken; and he has secured the finest photographs of star spectra yet obtained. The advance thus made is most important, for the spectra can now be measured and compared at leisure, free from all the difficulties which beset the direct analysis of the star-light.

In the magnificent physical observatory which has just been constructed at Potsdam, near Berlin, no expense has been spared to provide it with the best optical instruments. Dr. Vogel, the director, says that the spectroscope made by Hugo Schroder, of Hamburg, is a splendid instrument, and its twenty-one single prisms, combined into a system on Rutherford's plan, will enable him to measure one-hundredth part of the space between the D lines, and shows in the same space nine fine lines. When I saw this statement recently published, it recalled the information I had given you in November, 1875, viz., that nine fine lines had been seen at Berlin between D 1 and D 2 with the spectroscope then in use; that some years previously (1868) Dr. Huggins, using the great spectroscope at Oxford, saw twelve lines in the same space; and that Colonel Campbell, with a spectroscope made by Hilger, had in London seen nineteen lines between the two Ds; and comparing these statements with my own experience here, using a much finer spectroscope (also by Hilger, of London) which shows me seven lines between the two Ds, I was led to think that these differences must be due to atmosphere, and not to the quality of the spectroscope. If so, it is a most important question to determine; and I have therefore carefully examined these lines with our large spectroscope, which has a dispersion

equal to eighteen, 64° prisms, while Colonel Campbell's was only equivalent to eight. The measuring apparatus of mine also admits of measuring one three-hundredth part of the space between the D lines. In order to identify the lines I have numbered them 1 to 7, beginning at D1, and their positions as determined by a number of readings with the micrometer are as follows:—

D1	1	2	3	4	5	6	7	D2	D3
000	41	67	124	151	173	213	232	291	299

4 is the nickel line always seen; 7 is the position or very near it of the zinc line; 1, 2, 3, 5, and 6 are evidently atmospheric lines, as they increased in distinctness very fast as the sun neared the horizon; 4 also seems to enlarge as if there were an atmospheric line coincident with it, and 6 increased faster than any other; when the sun was near the horizon it was as thick again as D1; 7 did not increase at all, and almost disappeared when the sun was near setting.

The line D3 has not, I think, been described before. It is a difficult line to see, and only to be made out with high powers. I have not reduced my measures to wave lengths, because the results obtained by Dr. Huggins and Colonel Campbell are only recorded in drawings, without measures. I have had prepared enlarged drawings of those obtained in Oxford and London, with a careful plot from my own measures, which I now show you.

There are not many of the lines which agree; but as Dr. Huggins used bisulphide of carbon prisms, and Colonel Campbell only eight prisms, some of the differences might disappear if all could be reduced to wave lengths. On closely comparing the drawings, it will be seen that five lines were recorded in London between my 7 and D 2, two others between D 1 and No. 1, and three between Nos. 2 and 3. These spaces appear in Sydney, even under the most favourable conditions, entirely free from lines, or any sign of them. It would appear, therefore, that there must be some gases in the atmosphere of Europe, and

especially of London, which are not present in Australia. Whatever these may be, they have eluded chemical analysis, and they may prove to be of importance in judging of the purity of an atmosphere. If it should prove so, it will be rather curious that we are obliged, after all, to use our eyes to see what we breathe. Whether these lines indicate substances which make the difference between health and disease, cannot yet be decided; but there is no doubt that the air at times contains the cause of disease in such a subtle form as to elude all the ordinary modes of investigation.

Astronomers have this year to chronicle another temporary star, showing spectroscopic evidence of a sudden and extraordinary increase in its temperature. The new star, which was discovered on the 24th of November last by Professor Schmidt, of Athens, was of the third magnitude, and not far from Rho Cygni. On the 2nd December it was spectroscopically examined by M. Cornu, of Paris, and found to give a spectrum of bright lines, the positions of which were fortunately determined, although the star was then only of the fourth or fifth magnitude. Eight lines were measured, and five of these were found to be almost exactly coincident with C, D, E, F, and G of the Frauenhofer lines. So that the principal lines in the star spectrum coincide with the brightest lines of the sun's chromosphere seen in total eclipses, which seems to prove that the materials of the star were in a state of incandescence. It will be remembered that a still more remarkable star, giving a bright line spectrum, appeared in 1866—T. Coronæ Borealis—and in ten days faded beyond the limits of unaided vision.

Mr. Crookes seems disposed to give up the theory that the radiometer motions, or any part of them, are due to light only, for he says:—"I have recently succeeded in producing such a complete exhaustion in the radiometer that I have not only reached the point of maximum effect, but gone so far beyond it that repulsion nearly ceases, and the results I have thus obtained seem to show conclusively that the true explanation of the action of the radiometer is that given by Mr. Johnstone Stoney,

according to which the repulsion seen in the radiometer is due to internal movements of the molecules of the residual gas."

On the other hand, a French *savant* (M. Ledieu), in a paper read before the French Academy, remarks, that the theory which explains the action of the radiometer by saying that light falling on black discs becomes heat, and so establishes a difference in temperature between the discs and the gas in the case, which produces the motion, expressly requires that there shall never be an equilibrium of temperature between the discs and the gas in the case of the radiometer; but this cannot be admitted, for the arms keep revolving at a uniform speed so long as the light is present. He had tried many experiments, and in one of them the instrument was heated nearly to redness, and the discs began to move, but the speed was sensibly accelerated by the momentary presence of a single flame, which joined its action to that of the radiant heat; and he had obtained perfect rotation in an instrument in which both sides of the disc were equally polished.

It will be remembered that in 1872 Herr Groneman, of Göningen, propounded a new theory of the origin of the aurora. His hypothesis is that there are in space streams of minute particles of iron, revolving about the sun in the same way that meteors do, and that these, when passing the earth, become attracted to its poles, and from them stretch out as long filaments into space; but as they meet the earth's atmosphere with planetary velocity, they become ignited, and thus form the luminous aurora, giving with the spectroscope a green iron line. He has recently returned to this theory, and brought forward much additional matter in its favour. In connection with this subject the researches of Professor Nordenskiold are very interesting. He has been examining the purity of snow, both at Stockholm and near the North Pole. To north-west of Spitzbergen he found the snow contaminated with minute black particles, which proved on examination to be exactly the same as those found at Stockholm, and consisted of particles of metallic iron, phosphorus, cobalt, and fragments of Diatomaceæ.

From observations made in June last on two bright spots seen on Jupiter, Mr. John Brett infers that such spots have a proper motion on the surface of the planet, and that they are globular bodies almost as large as the earth; and he further infers, from their gradual disappearance as they approach the limb, that they are wholly immersed in the semi-transparent material of the planet. The rate of proper motion assigned to them is 165 miles per hour.

A most interesting inquiry is opened up by this observation—viz., whether there are such bodies revolving about Jupiter. The white and black spots so frequently seen, though better defined in outline, would seem to belong to some such system. Analogy of course would teach us to expect such forms as the results of cyclones in the atmosphere of a planet, in consequence of its rotation. But the rate of motion—165 miles in a hour—is certainly a difficulty, as the motion of storm centres on the earth is only 4 to 6 miles per hour; but it must not be forgotten that there are some barometer waves transmitted through our atmosphere at the rate of 50 miles an hour.

Professor Hall, of Washington Observatory, using the great 26-inch refractor, recently detected a small well-defined white spot on the planet Saturn. It was reported to six other American observatories and carefully watched; the mean of the observations gives a rotation period to the planet of 10 hours 15 minutes, which agrees very well with Sir. W. Herschel's determination, made in 1793-4, of 10 hours 16 minutes 0-4 seconds.

Professor Langley, of Allegheny Observatory, has just published some results of his solar observations, and gives it as his opinion that the solar atmosphere is proved to be a thin stratum, which cuts off one-half of the heat that would otherwise reach the earth. This, he considers, is proved by its action in producing the dark lines in the spectrum, or, in other words, stopping the light and heat of the sun; and he calculates that should this envelope be increased 25 per cent. in thickness, the mean temperature of our globe would be reduced 100° Fahrenheit, and possibly some such phenomenon took place in the glacial period.

The pendulum experiments which have been carried on in India in connection with the Trigonometrical Survey since 1865 have been reduced at Kew, and, it is said, offer incontestable evidence in confirmation of the hypothesis of a diminution of density in the strata of the earth's crust which lie under continents and mountains, and an increase of density in the strata under the sea.

The progress of meteorology during the past year has not been so rapid as many persons desire and think possible, but there can be no doubt that the widespread interchange of ideas and observations is tending to place meteorology in the position of a true science, from which we may expect a complete account of the motions of the earth's atmosphere and ocean, as well as of the various other elements which form climate; as well as the relations which subsist between them; and the cosmical phenomena which, without doubt, have much to do with the changes we see. Each step in advance seems to bring fresh proof of the intimate relations which subsist between the earth's atmosphere and the sun's surroundings, and of the necessity for combining the study of these branches of science.

How far the former is a result of the latter no one is at present prepared to say; but the many efforts which have been made to show the dependence of meteorological changes on sun spots, and the amount of evidence brought forward to prove it, show how commonly the belief is entertained by those who reason on the subject.

Meantime meteorology is rapidly extending its practical side, and the great success of weather maps and storm warnings in England, France, and America, especially the latter country, has led to their adoption by other European States; and there seems little doubt that Europe will soon be covered by an international system which will afford as much information to the seaman and the farmer as the weather-map of America does. In Australia we may congratulate ourselves on having made a beginning; and the weather-map that has been published daily in Sydney since the 3rd February, 1877, is only the first of a series which will be published daily in each Colony; by which means the information which is now being freely exchanged by the four Colonies, South Aus-

tralia, Victoria, Queensland, and New South Wales, will be placed before the public. As the method of producing the weather-map here is novel and different to that adopted in England and America, perhaps a few words of explanation may be devoted to it. In England, after the telegrams are received, a map is prepared by hand for lithographic printing, and 500 copies are printed by 3 p.m. each day, and distributed to subscribers, who pay a moderate sum for the information. Several of the daily newspapers reproduce portions of this map by engraving it on a block, and taking a cast from it, which is again stereotyped; such at least was the method when I last heard. In America a stock of outline maps of the States is kept ready to receive the weather information. Such parts of it as can be given in type are set up and printed on the outline map. The isobars are then put on a lithograph stone and printed on the map, which is then transferred to the stone containing isotherms, and there receives its fourth and last printing, and is ready for distribution early in the afternoon; but it is not, so far as I am aware, reproduced by the newspapers. About 2,000 copies are distributed daily by post, and must of course take days in reaching some places.

In Sydney the map is prepared in this way:—A block of metal of the size of the map, and one-eighth of an inch less in thickness than the height of ordinary type, has fixed upon it an electro outline of the coast and mountains of the eastern half of Australia; the electro is just of the thickness required to make it type high. At the position which each station occupies a hole is cut in the block, of the right size to receive the wind symbol, and the type necessary to express the force of wind, height of barometer, letter for rising or falling barometer and the temperatures. Spaces are also cut out to receive the list of temperature and rainfall, also for the explanatory matter. The rest of the block is flat, and, as I have stated, ⅛-inch lower than the type. When the telegrams have been reduced and corrected, they are given on a convenient form to a compositor, who in a short time makes all the changes that are necessary to convert the figures of yesterday into those of to-day.

The compositor has also a set of sea symbols, wind arrows, words, &c., to express any information that is to be given on the map; these are simply glued on to the block wherever they may be required, and as they are only ⅛-inch high, they just come to the height of the type. If any curves are required on the map, they are bent by hand from strips of soft metal rolled ⅛-inch high, and are glued on to the surface in the same way as the other symbols. As soon as this is done it is ready to print from in an ordinary press, and a few copies are printed off for distribution. The map is then sent to the *Herald* Office, and there stereotyped for the morning's paper, after which it is returned to the Observatory for next day's map. In this way it is thought that the information reaches the public sooner than it could by any other method. There is, however, nothing to stop the issue of copies each day soon after noon if thought desirable; for it is evident that the time required to prepare this map is less than others referred to, and printing from type can be done much quicker than from a lithograph stone.

Turning now to other matters: it will be remembered that experiments on the amount of sunshine were made in London, by placing a globe of clear glass in a hemispherical cup of wood, and estimating the amount from the wood carbonized. The method was, it is true, exceedingly rough, but it yielded an interesting result; unfortunately it turned out that no satisfactory estimate of the amount of energy could be obtained. Dr. Roscoe invented a small machine to get over the difficulty, by exposing, at regular intervals during the day, small pieces of sensitive paper, with the object of calculating the sun's heating power from the amount of silver decomposed, but it has not been found to give the information required, that is, a continuous record of the sunshine. Mr. Scott, Director of the Meteorological Office, London, has now designed a modification of the original instrument. Instead of wood to be burnt he uses slips of cardboard ruled into hours; these are placed daily at the back of the glass bulb, and each day therefore has its own record. This is a great improvement, but we are not told how the effect

is now to be measured; and there is some difficulty in the way, since the weight of the cardboard would vary with the state of the weather, and this would be a serious difficulty if the sun's effect is to be ascertained by weighing.

In connection with this subject, it will be remembered that about seven years since a French inventor, M. Mouchot, exhibited before the Emperor a steam-engine worked by direct sun heat. He has been working at the machine ever since, and some of his recent results are so good that it seems probable that direct sun heat may in warm, fine countries become an economic source of power.

The machine is thus constructed:—A mirror in the form of a truncated cone, 74 inches in diameter, has its axis converted into a boiler 11 inches in diameter and 31 inches high. With this the mirror makes an angle of 45°, so that all the rays falling on it are reflected into the boiler. To prevent loss of heat by radiation, the boiler is covered with an air-tight glass case. This apparatus is placed on an axis parallel to that of the earth (a polar axis) and then turned so that the axis of the cone points to the sun. Clock-work is then connected to the polar axis, and keeps the mirror turned to the sun. The results obtained in ordinary weather are as follows:—4 gallons of water introduced at a temperature of 68° Faht. at half-past 8 a.m. were turned into steam of 30 lbs. pressure per square inch in forty minutes. The pressure was then allowed to rise to 75 lbs. on the inch, which it did in a few minutes, but the boiler was not strong enough to carry the test to a greater pressure. The steam was used to drive an engine and a pump. At another trial the machine distilled a gallon of wine in fifteen minutes.

These are surprising results to be obtained in the climate of France, and seem to make the experiment worth trying on our sunny plains.

Another use, however, might be made of it. Such an instrument, properly constructed, might be kept at work always, and made to deliver the water distilled into measures placed at fixed

intervals (hours or minutes) during the day, and the water so collected would form an exact measure of the sunshine.

Mr. Glashier, in a paper on the mean temperature of every day at Greenwich, from observations taken there from 1813 to 1873, has made a valuable contribution to science. The results have been plotted into a curve, representing amongst other things the variation of the temperature throughout the year. From this it appears that in January the curve is normal, but in February there is always a considerable rise between the 5th and the 10th of the month, and a fall between that and the 15th. The curve is rather unsteady during March and April, and in May it shows a remarkable depression between the 10th and the 15th, which Mr. Glashier thinks is probably due to some astronomical cause. The curve also shows rather sudden depressions about the 30th June and 8th July, and is then normal until the 5th or 6th of November, when a remarkable depression sets in and lasts about three weeks. (During this time the earth passes through the November meteor shower.) During December the curve is normal again. Considering the length of the series from which these results are obtained, it would seem probable that all the irregularities in the curve are due to some external cause; or, in other words, to the intervention of something between the earth and the sun, which for the time adds to or absorbs the sun heat.

Turning from these interesting *mean* results, we find that during the year extremes have been reached both *in* the earth and near the pole. A remarkable series of observations on underground temperatures have been taken in a boring made at Sperenberg, near Berlin. The bore was carried to the extraordinary depth of 4,172 English feet. The first 283 feet of it were made in gypsum, with some anhydrite, and the remainder entirely in rock-salt. The greatest depth at which the temperature was obtained was 3,491 feet, as the upper part of the bore was lined with iron pipes, and could not therefore be plugged to prevent convection of heat. The first temperature was taken at 721 feet from the surface. Two plans were adopted for securing the actual

temperature of any part of the bore. First, in sinking it, when the temperature was to be taken, a smaller bore was driven in advance for several feet; into this the thermometer was lowered, and a wooden plug driven into the top of the small bore, so as to prevent convection affecting the temperature. After the thermometer had remained in from twenty to thirty hours, it was withdrawn and read. The other method was, to cut off by means of two plugs sections of the well, in which a thermometer was kept about the same number of hours. I give the results of these measures:—

Depth in feet English.	Difference.	Temperature corrected for pressure, Faht. scale.	Difference.	Increase per 100 feet.
		*48·2		
721	206	70·9	......	......
927	206	74·3	3·4	1·7
1,133	206	79·6	5·3	2·7
1,339	206	80·4	0·8	0·4
1,545	206	84·4	4·0	2·0
1,751	206	87·6	3·2	1·6
1,957	206	91·6	4·0	2·0
2,163	206	96·5	4·9	2·5
3,491	1,328	115·8	19·3	1·5

* Mean temperature of air at the well.

This gives an average of 1° Faht. for every 51·5 English feet, and the increase for the last 1,300 feet was not so rapid as in the higher levels.

Turning now to the other extreme, we learn from Captain Marham's letter to Commodore Hoskins, *re* Polar Expedition, that:—

"The cold up to the end of February, 1876, was not felt severely, although the temperature was ranging from – 30° to – 60°; but during the last few days of that month and beginning of March the cold was intense, the temperature falling as low as – 74°. This, I believe, is the lowest that has ever been recorded. In this temperature glycerine became perfectly solid and quite transparent, rectified spirits of wine became of the

consistency of hair-oil (for want of a better simile), whisky froze hard, and we were able to break off pieces and eat it. Concentrated rum, 30 o.p., also froze hard in a shallow saucer, and in a bottle resembled frozen honey or molasses in regard to thickness. On chloroform, however, no apparent effect was produced. The lowest mean temperature for twenty-four consecutive hours was – 70·3; for thirty-six consecutive hours it was – 69·93, and for six days the mean was – 60° or 92° below freezing point. Latitude of station, 83° 20′ 26″. May 12, 1876."

It will be remembered that the lowest temperature ever recorded in balloon experiments was 44° below freezing point – 12°, at six miles high (32,000 feet), on September 5, 1862.

I have already detained you too long, and with just an allusion to an interesting question raised by Mr. J. A. Brown, of London, I will close. Mr. Brown, in a paper on simultaneous variations of the barometer, shows, from observations made in Europe, Asia, Africa, America, and Australia, that during the week, March 31 to April 5, 1845, all the barometer curves exhibit a maximum near the beginning, and another near the end of the week, with a minimum near the middle; and he asked whether there may not be other causes of varying atmospheric pressure than a change of the mass of the air; in other words, whether the attraction of gravitation is the only force concerned in barometric oscillations. Admiral Fitzroy strongly objected to the theory that the curve of the barometer indicated the height of atmosphere over it, or that it represented atmospheric waves; and he thought these effects were due to the action of the polar and equatorial currents on each other, and showed that these waves of pressure travel to north-east and south-west, and are quite distinct from the local changes in pressure due to storms, &c. Their rate of motion also is quite different from that of storms, which make from 4 to 6 miles per hour only; while these waves of pressure travel here over south-eastern Australia at the rate of 20 miles, and in some cases 50 miles an hour. They are a very marked and interesting feature in our meteorology, and their uniform progression over the whole of south-east of Australia at the rate mentioned seems

to me at variance with Fitzroy's theory that they are caused by air-currents. A glance at the curves, plotted for a year over the whole Colony, shows that these waves uniformly travel from west to east, and in most cases so rapidly that the crest appears all over the Colony on the same day. Such a rapid translation seems to me to point to some external cause; and on comparing Sydney barometer curves for 1873 with those of Greenwich for the same year, I was struck with the number of coincidences in the character of the curves. In many cases the points of elevation and depression occur on the same day at both places, and in several instances the curves follow the same form for more than a month. There are great temporary differences, due no doubt to local causes, but the similarity is very striking.

It is somewhat difficult to see what could make a simultaneous loss of atmospheric pressure in the two hemispheres, unless it be the heat of the sun acting more intensely on the equator, and so making a great demand on the trade winds which are supplied from temperate latitudes, and would, in that case, draw off the pressure. The fact that such a loss of pressure causes an in-rush of polar wind seems to confirm this view. That there are such sudden changes in the sun's heating power has been shown in many ways, and notably by Mr. Glashier, in the paper I have alluded to to-night.

The Forest Vegetation of Central and Northern New England, in connection with Geological Influences.

By W. Christie.

[*Read before the Royal Society of N.S.W.*, 4 *November*, 1876.]

In venturing to consider the subject of forest vegetation in connection with its geological influences, I purpose limiting my remarks to that portion of the Colony with which my ordinary avocation has, by bringing me into daily contact with it for the past few years, made me the more familiar, viz., Central and Northern New England.

Various important reasons have led me to thus limit the territory under consideration. The first is—That by confining myself to one district, with which I am intimately acquainted, my remarks will be more accurate and reliable than would be possible were I to extend them to those portions of the Colony over which my observations have been more limited and casual. Secondly—That the region in question presents a sufficiently varied geological character to illustrate many of the effects of geological influence on the indigenous forest vegetation. Thirdly—That, inasmuch as the climate of this region is nearly uniform over its whole extent, the question may be considered more directly within itself than it could be were the complications arising from climatic changes to be entered upon in connection with it. And fourthly—That as the general rules which may be strictly applicable in this and other districts having a similar climate may and in fact in many cases do not apply in those districts which, from geographical position or other causes, are subjected to different climatic influences, it is probable that the interests of the subject under inquiry may be better served by first considering the rules obtaining in separate and limited areas; and then, by considering their differences in connection with the known effects of climate on vegetation, we may arrive at a knowledge of those laws which appear to govern the forest growth in connection with its geology. It is with the view only of offering my contribution to the first of these aspects, that I have ventured to compile my notes on the subject, feeling that the question in its entirety involves

so many and varied considerations, which are intimately blended one with the other, as to render it almost impossible to even touch upon them all in a brief paper like this.

Having been disappointed in arrangements which I had made for the illustration of my remarks by photographs of portions of the characteristic forests of this district, I have adopted what I conceive to be the next best course, viz., that of accompanying them with specimens of the principal timbers and soil. The specimens number about sixty, and I trust will give a tolerably clear idea of the various combinations of soils and timbers which I purpose to consider. Of the genus *Eucalyptus*, which occupies by far the most prominent place in the forests of New England, I have collected twenty species. The total number inhabiting this district probably amounts to thirty or more; but while a large number of the varieties of this genus which prevail on the eastern slopes below the steep escarpments which so well define the boundary of the plateau to the east does not ascend to the elevated and colder regions of New England, and many varieties which are common in the region to the west of the table-land do not encroach upon its naturally defined limits, there are yet some which, I believe, are peculiar to it. Those are, at any rate, not found on or below either of the slopes, nor have I seen them in any other part of the Colony north or west of Murrurundi.

As an instance of this change of species, which occupy apparently the same relative positions in different localities, and as showing the difficulty of defining any general conclusions from observations in any one district, I will mention the river gum of of the interior (*E. rostrata*). This tree, according to Dr. Woolls, does not occur at all to the east of the Dividing Range. It is, however, common on the western rivers. I have observed it on all the waters from the Mooki and Namoi Rivers north to the Dumaresq. It lines the banks of those rivers to within a few miles of the plateau, when it generally yields its place to the river oak, one of the *Casuarinæ*. On the plateau, however, the gum-tree which occupies the place of *E. rostrata* under exactly the same conditions, so far as soil and geological formation are concerned, is known by the local name of "Sally" (described No. 8). The name is probably a corruption of *E. saligna*. (I do not think, however, that this is the species which frequents the low grounds about Parramatta, as mentioned by Dr. Woolls in his "Flora of Australia," p. 231.) But on the eastern waters a species distinct from either of those mentioned frequents the river banks. It is known as the flooded or blue gum (*E. Eugenioides*).

The fact of those three species inhabiting the same kind of soils and localities in their respective districts, while neither of them appears to encroach on the territory of the others, seems to show that they are not only influenced and kept within their own

proper limits by climatic influences, but that the impregnation of the atmosphere by the salts of the ocean has some share in the division of the forest vegetation. What that share is, or what influence the climatic effects exert, is beyond the object of this communication; but they may be incidentally refered to, where a comparison between the occurrences on the plateau and those in its vicinity may tend to eliminate any point in the inquiry.

The greater portion of Central New England is composed of granitic formations. These occupy very large tracts, and in the stanniferous regions the country is generally characterized by rough, almost inaccessible, ridges, covered with huge blocks, alternating with swampy valleys of a soft, rotten nature, over which in wet weather it is almost impossible to travel. The granite for the most part is similar to specimens marked Q, and the soil formed from its detritus retains a very large amount of moisture; so that if the wheels of a vehicle break through the outer crust, the argillaceous matter from below spirts up and is soon worked into a bog, out of which it is almost impossible to be extracted. Numerous tracts of such country as this occur about Guy Fawkes and Oban; and the Dividing Range, between the Severn and Mole Rivers, is composed almost exclusively of such formation. Those localities are all characterized by the same description of forest vegetation. Stringy-bark (specimen 19), *Eucalyptus amygdalina*, attains here large dimensions, more particularly in the rough and elevated ranges, where it is the prevailing timber, and is usually accompanied by undergrowths of saplings, *Acacia*, and frequently *Banksia integrifolia*. There the sward is generally composed of blady grass and rushes. Tracts of undergrowth of scrub oak generally occupy the summits; but as we descend into the valleys, the peppermint (specimen No. 13), *Eucalyptus hemiphloia*, mixes in the forest with occasional red gum (specimens 2 and 2A), *Eucalyptus resinifera*, and blue gum (specimens 3 and 3A), *Eucalyptus tereticornus* (?) As we leave the more rugged tracts, the peppermint becomes more and more the predominant timber; and frequently the low ridges forming the valleys of the larger streams are clothed with a fine open forest in which no other timber mixes. This timber is almost invariably found on granitic soils, and generally where it occurs the undergrowths are less dense, and the grass richer and better than in other growths on those soils. On the banks of the streams in such localities the sally occurs, and occasionally enters into combination with the peppermint for some little distance back. The small-leafed shrubby tea-tree, *Leptospermum parvifolium*, grows in the bed of the streams, but is never found beyond the limits of the bank. In those tracts in which the granite contains a larger proportion of quartz than that described, various species of the group *Leiophloiæ*, smooth-barked trees, of the genus

Eucalyptus, mix in the forests. The most common of these are the white gum (specimen No. 9), *Eucalyptus hæmastoma*, the grey gum (No. 7), *Eucalyptus sp.*, red gum (Nos. 2 and 2A), *Eucalyptus resinifera*, and a species of spotted gum (Nos. 1 and 1A), *Eucalyptus sp.* There are, I think, only four members of the group *Hemiphloiæ* found in this district, two species of yellow box, the white box (*E. hemiphloia*), and a timber sometimes called black-but, and sometimes messmate, *Eucalyptus obliqua* (Nos. 10, 20, 11, 12). The white box, so far as I have seen, never occurs on granitic soils. A species of yellow box (No. 20), however, appears to be peculiar to granitic, elvanite, and sandstone formations, and is so very like the white box that it is frequently taken for it. This tree, however, has a small leaf, and the shape of the seed-vessel is quite different from that of the latter; it is also very much more fully barked, and, on examination, I have found that in various localities in which box was said to exist on granitic or elvanite soils that this tree had been mistaken for it. The other three members of this group, however, are in some localities numerous among the combination mentioned, and it appears that the more sandy the detritus from the granite is, owing to the larger amount of quartz contained therein, the greater the diversity of this genus, and the greater the liability to the intrusion of trees of other characters. The *Banksia integrifolia* (No. 38), *Acacia*, and various undergrowths, generally occur more plentifully in those soils. It may be worthy of remark that, in all the localities of this district in which I have seen the *Banksia* growing, molybdenite has been or may be obtained in the rock. This, however, is probably accidental.

The soils of granitic formation are generally considered unsuitable for sheepwalks. It is certain that on those soils sheep are very susceptible of "foot-rot" and "bottle," unless they are under very careful management; but that they *can* be profitably kept on them is proved by the fact that during the past few years numerous farming selectors have settled on this formation, and, having given their attention to sheep-breeding, are becoming quite prosperous on portions of country which were said to be unfit for anything but cattle. At Wellington Vale, which is of almost exclusively granitic formation, under the able superintendence of my friend Mr. A. E. Gaden, I recently saw an offer of £2 per head refused for 100 out of a small flock of 300 ewes which had been bred on that run. These facts are more eloquent than language, in pointing out what may be done by careful attention on the generally despised granitic sheep runs.

With reference to the "bottle" disease,—a selector about two years ago pointed out to me a small plant which he called the bottle weed, and he assured me that sheep contracted the disease by eating it. The plant grows to a height of from four to six inches,

bearing a small pink flower; and having had my attention thus directed to it, I watched it carefully on every opportunity that offered, and find that it is carnivorous, preying upon gnats, mosquitoes, and such small winged insects; it is botanically known as *Drosera peltata*.

The weed, however, grows on swampy or damp granitic or elvanite flats, and it is in those localities that the bottle disease is generally contracted. Whether the plant really has anything to do with it, I cannot of course say; but I think it more likely that the disease arises from the animals inhaling some miasmatic atmosphere obtaining in those localities to which the plant is peculiar.

The apple tree (*Angophera subvelutina*) occurs in some localities on granitic soils; but there appears to be a difference in the leaf between this and the apple tree of black basaltic alluvia. In the latter tree I believe the leaves are invariably opposite, with a very short petiole; but in the former, numerous branches may be obtained on which the leaves are alternate, and having a petiole of from half to three-quarters of an inch in length, giving the tree the appearence of having been influenced by hybridization. In other respects I have been unable to trace any differences between them.

In those tracts covered by elvanite formation, which are numerous and extensive on the north-western slopes of New England, as well as in many other localities scattered throughout its area, and which occupy a large proportion of the rough and broken country lying between Strathbogie and the Dumaresq River, the vegetation is characterized by plants which seldom, if ever, occur in granitic soils. The yellow ironbark (No. 17), *Eucalyptus leucoxylon*, and the common ironbark (No. 18), *Eucalyptus siderophloia*, occupy the most conspicuous place in the forest, and are frequently accompanied by a stunted red gum (a smooth-barked tree, attaining a height of fifteen to twenty feet, with a diameter seldom exceeding twelve inches), and occasionally by stringy-bark. In the warmer portions, such as at or near the base of the mountains forming the southern side of the valley of the Dumaresq River, and where the character of the rock merges more into that of sandstone, pines occur to a limited extent. On those soils (the characters of which are exhibited by specimens marked A, H, IH, and M, from various portions of the district) the dogwood (*Jacksonia scoparia*) and grass-tree (*Xanthorrhœa media*) are invariably found as undergrowths, accompanied by a stunted species of acacia. Most of the undergrowths of this soil are exhibited by specimens Nos. 21 and 29.

The timbers generally on this class of soil are hollow, and do not attain that luxuriant growth which marks most of the vegetation occurring on granite. This is frequently more marked

in those localities contiguous to soils of a more fertile kind, such as where basaltic formations overlie the elvans, and the timbers generally appear to dwindle and lose a great portion of the limited vigour which they attain at a greater distance from the better class of soil.

In localities where the prevailing rocks are micaceous quartzose granite, with numerous outcrops of quartz and dykes of slate (as specimens R, S, and T), such as on the Dividing Range between Dundee and Glen Elgin, scrub oak, and two or three species of acacia, among which is that known as *Lignum vitæ*, combine in forming dense undergrowths in a forest composed for the most part of stringy-bark and red gum. Forest oak is of frequent occurrence on the adjacent flats in this and the preceding formation; but this timber appears to be more common about their edges, where the detritus from the adjoining formations mix. Under such circumstances there is always a marked difference in the forest vegetation, as the different species which abound on the separate formations in their pure state become combined in the same groups, and frequently trees which are not to be found in either take up their positions here. The spotted gum (Nos. 1, 1A) *Eucalyptus species*, in many cases assume very defined limit under those circumstances, when it is not found growing in either of the surrounding soils.

New England owes much of its prosperity to the influence of its extensive tracts of soil of basaltic origin, which extend over a very large portion of its western slopes, and form those rich alluvial flats which offer so great an attraction to the agriculturist, and the good sound ridges, so excellent as sheepwalks.

On those soils the effects of climatic change on the forest vegetation appear to be more visible and marked than on any others in New England; and although they vary considerably in different localities, and generally the variations are distinguished by a corresponding change in the vegetation, yet in most cases the changes, owing to climatic effects, are so well marked that no reasonable doubt can exist as to their cause. For instance, the white gum (No. 9), *Eucalyptus hæmastoma*, in the colder portions, such as about Ben Lomond and Glen Innes, forms open forests, for the most part of large timber, with a slight intermixture of peppermint. On rich black basaltic soils it is almost wholly replaced as we approach those warmer regions below the falls to the west by the white box (*E. hemiphloia*). The peppermint disappears altogether on exactly the same class of soil on which it flourishes in the lower temperatures, while the number of species of the genus *Eucalyptus* which enter into combination appears to be increased.

On the soils of the colder regions the prevailing timbers are this species of white gum, with apple-tree; the vegetation in the

warmer is usually composed of white box and apple-tree, intermixed more or less with yellow box (sp. No. 10), *E. bicolor* (?), two species of white gum (Nos. 5 and 9), *Eucalyptus Stuartiana* (?) and *Eucalyptus hæmastoma* and a little acacia and native cherry (*Exocarpus cupressiformis*). These latter, however, are common in both the climates as an occasional undergrowth to the forests named; but while they are frequently found in this class of soils, they are by no means peculiar to it, being found largely in argillaceous rock formations, granite, &c.

The rich red friable basaltic soils, such as specimen marked G, appear to be always characterized by a forest growth, consisting for the most part of stringy-bark (36), with one or two specimens of half-barked trees, such as messmate or blackbut, with a dense undergrowth of wattle, acacia, and wild hop (*Daviesia latifolia*). A very large tract of this class of soil occurs to the west of Vegetable Creek, and another of similar nature, but smaller, at the back of Glendon estate. Those localities differ some 1,500 feet in elevation, but the vegetation is very similar throughout. There is a similar tract of country some 20 or 30 miles north-easterly from Tenterfield, and another 10 miles north of Wellington Vale. Although those localities differ considerably in elevation above the sea level, and their climates vary quite sufficiently to show their effect on the forest vegetation, so far as other timbers are concerned, they are all characterized by the same kind of vegetation; and I have never observed any timbers on one of them that are not found on the others.

The white box appears to grow chiefly on stiff red or black trappean soils, and while it occupies the largest portion of the ridges and elevated ground, the apple-tree (*Angophera subvelutina*) predominates on the flats. A white gum (specimen No. 9), however, occasionally grows in those situations—in fact, so far as the particular region in question is concerned, this species appears to be common to more classes of soil than any other; but on the colder portions the parasite *Loranthus aurantiacus*, a species of mistletoe, is common on it, while in the warmer regions it is of more frequent occurrence on the red gum (specimens 2 and 2A), *E. resinifera*, which for the most part grows on poor soils.

On those soils the Darling pea (*Swansonia galegifolia*) appears to flourish luxuriantly. This pest is gradually but surely making its way up to the table-land from the warmer and richer regions to the west, and is a source of great trouble and annoyance to flockmasters. Two years ago this plant was comparatively rare on the Rocky Creek Run, which is situated to the east of Ashford, and just within the confines of New England; but I was informed the other day by Mr. Gordon, proprietor, that at the present time this noxious weed had spread to such an extent as to curtail the carrying capacity of the run by nearly one-half. I have not

yet observed this plant on the table-land, and I trust that many years will elapse before it makes its appearance there.

The Bathurst burr (*Xanthium spinosum*) and two species of thistle have, however, not only made their appearance on New England, but are already making considerable havoc on many of our best tracts of agricultural land. Those well-known plants appear to be little affected by the influence of either soil or climate; wherever the seed may chance to be dropped they spring up most vigorously, soon choking all the other vegetation which existed on the spots overrun by them.

The degree of decomposition which the highly ferruginous basaltic soils have undergone appears to have a considerable effect on the indigenous vegetation. On those rich friable soils, such as specimen marked G, which is from a continuous range which I have traced for more than 30 miles, and is almost all of the same character, with occasional pisolitic nodules scattered over the surface, the vegetation is throughout stringy-bark, acacia, wild hop (*Daviesia latifolia*).

This soil is to all appearance composed of exactly the same material as that exhibited in specimen B, but has undergone a greater amount of decomposition, to which, I think, it owes its much higher state of friability. On this latter, however, which for the most part in this district occurs in patches, the vegetation is in all cases totally different to what it is on the former, being a white gum—specimen No. 5—(*E. Stuartiana ?*) and apple-tree (*Angophera*), with occasional accacia. The line of division between those two soils is usually very easily defined; and although the patches of the latter, which consist almost entirely of pisolitic nodules, with very little real soil, may be entirely surrounded by other vegetations, they are seldom if ever encroached upon by them.

In reviewing the various facts which I have endeavoured, with, I fear, but inadequate success, to lay before the Society, with reference to the connection between the indigenous forest vegetation and the principal geological formations of Central and Northern New England, it will be observed that, while many of the timbers are common to various soils, and some are common to them all, there are others which frequent only one class. Thus, the common wattle (*Acacia decurrens*) is found in almost every formation; so also is the stringy-bark in some of its varieties, and many other trees of the genus *Eucalyptus*; but the timber known as peppermint (*E. amygdalina ?*) is almost exclusively found on granitic country, as also the "Sally" (*E. saligna*) and the grey gum (*E. coracea ?*). On this soil those timbers are generally found in the drier localities, while the stringy-bark frequents moister regions. Varieties of iron-bark—the dog-wood (*Jacksonia scoparia*) and grass-tree—frequent elvanite and por-

phyritic regions, and are seldom found on any other; while the white gum (specimen 5), *E. Stuartiana? Daviesia*, the wild hop, appear to be peculiar, or nearly so, to basaltic soils, and stringy-bark to those soils in its driest and most friable portions.

There appears to be an amount of regularity in the various combinations of timber trees in the forest vegetation in connection with its geological alliances which can hardly be accounted for, except by the supposition that there is some general law which governs them. Although the observations made in one limited district will probably not afford sufficient information on which to determine what that law is, still I venture to think that a comparison between its effects in a few districts where, the climates being known, their effects may be considered in conjunction, will so far illustrate its general principles as to render an acquaintance with them of great practical utility.

Nor do many of the effects of this law differ to so great an extent in various localities and climates as may perhaps be supposed. Many of them have for several years had their recognized significance in pastoral and agricultural matters. Such phrases as "Box Forest," "Iron-bark Ranges," "Apple-tree Flats," "Stringy-bark Ridges," "Myall Plains," &c., have all had their own respective associations in the minds of those interested in the pastoral or agricultural capabilities of land, ever since the Colony began to assume a prominent position in these pursuits; and, what is more, those associations are the same throughout all parts of this Colony and Queensland, showing that those timbers, being more widely spread than most other species, obey the same general law throughout. But the associations resulting from those observations were thus early arrived at because, involving as they did a large amount of pecuniary interest, the observers were much more numerous than they otherwise would have been; and while those results which immediately affect individual prosperity are well known, all the surrounding circumstances appear to point to the same geological influences over the other forest vegetation as control the few examples named, which, although subject to certain local variations arising from climatic or other considerations, are regular when the value of those causes of variation is considered and allowed for.

APPENDIX.

The following are descriptions of twenty-one species of the genus *Eucalyptus* found in Central and Northern New England. Specimens were exhibited at the meeting when this paper was read:—

Spotted Gum.—Group *Leiophloiæ* (specimens No. 1 and 1a.) —The bark of this tree is smooth, but more of a lead colour than most of the ordinary species, and is mottled with light and dark patches, caused by the falling off of the outer skin. *Leaf:* The leaves are lanceolate, from five to six or seven inches long, and alternate, supported on petiole 1 inch in length. The midrib is slightly above the plane of the leaf, and the marginal nerve is indistinct; a distinct nerve runs round the outer edge of the leaf. *Seed-vessel:* The umbels contain generally seven florets, six of which are set on the peduncle at right angles to it, and the seventh stands upright in the centre. The operculum is three times as long as the capsule, and is conical, the pedicle about a quarter of an inch long, and peduncle about the same length. *Wood:* The wood is hard and tough, and is said to be durable as fencing material. *Habits, &c.:* This timber grows generally about the junction of rich soil with that of a poorer class; in localities where the wash from a rich basaltic ridge mixed with that from granite or sandstone, this tree would be found growing. In some localities this is very much defined. At the Nine-mile Creek, where one ridge is basaltic and the other granitic, a tin miner informed me that he worked as far as the line of gums, and that the stanniferous washdirt never encroached on the ground occupied by them. The gums there are of this species, and I have observed that it always in this district grows under those conditions mentioned.

Red Gum.—Group *Leiophloiæ* (specimens Nos. 2 and 2a).—The bark of this timber is of a greyish-brown colour, and the wood is red, and very hard and brittle. It is a durable timber for fencing material. *Seed-vessels:* The umbels contain from seven to ten florets. The operculum, which is conical, is two and a-half times as long as the capsule. The capsule is four-celled, and the valves protrude. Its margin is not well-defined on the fully developed seed-vessels. A red streak runs round the junction of the operculum with the capsule. It sometimes has a smeared appearance, as if the streak had been drawn with red ink and partly wiped off again. *Leaf:* Alternate, and from six to eight inches long. When held to the light it appears mottled. It is of a dark bluish-green colour, not glaucous, and the midrib is prominent on under side. The marginal nerve is well-defined. *Habits, &c.:* This tree is found generally on patches of poor elvanite outcrops, among basaltic soils, in company with box and apple; but where the soil is granitic with elvans, its combination

is stringy-bark and iron-bark, with various undergrowths. The parasite *Loranthus aurantiacus* (mistletoe) frequently grows on this tree in the latter kind of soils.

Blue Gum.—Group *Leiophloiæ* (specimen No. 3).—This tree is very similar in general appearance to the spotted gum and red gum of this district. It is difficult to distinguish between the barks of those three timbers. The wood is hard and brittle, of a deep red colour, and has a high specific gravity. The leaf is ovate on this species, whereas on the other two named above it is lanceolate. It is of a bluish-green colour, slightly glaucous; the midrib is prominent on both sides of the leaf, and the veins are very distinct. Generally alternate, but sometimes opposite, the leaf is from 4 to 5 inches long and 1 wide, supported on petiole of ¾ of an inch in length. *Seed-vessel:* The seed-vessel differs considerably from all the other species on New England. The umbels are not regular in either the number of florets or their systematic arrangement on peduncle. Many of the florets appear as if they had been stuck on at random. The operculum is two and a half times as long as the capsule, and is of about the same dimensions throughout, having a blunt, rounded extremity. The capsule is thicker than the operculum, and forms a defined step at the junction, looking as if the operculum had been stuck *into* the capsule. The peduncle is three times as long as the pedicel, and twice as long as the capsule. The vessel, after parting with the operculum, has a well-defined lip round the orifice, through which the valves, which are very pointed, protrude. It is sometimes three and sometimes four celled. *Habits, &c.:* Grows chiefly on poor soils, partly granitic and partly elvanite; accompanies iron-bark, stringy-bark, and some other gums. In the swampy portions of such soils a plant known as *Drosera peltata*, or *bottle-weed*, which is a flesh-eater, grows.

Blue Gum.—Group *Leiophlioæ* (specimen No. 3A).—This tree, in the arrangements of the florets in the umbels, is somewhat similar to the previously described blue gum, and the barks are very similar; but the wood of this species is not so red, nor does it appear to be so hard. The leaf is more lanceolate than that of the tree named. The midrib is prominent on both sides of the leaf, and the marginal nerve and veins are coarse and well-defined. The leaves are alternate. The petiole is three-fourths of an inch long. *Seed-vessel:* The operculum is two and a half times as long as the calyx, and before it is cast off the vessel has a blooming red mottled colour, similar to that on ripening peaches. The peduncle is about as long as the operculum and calyx together. The umbels generally start from junction of leaf stem, but not always; this appears in some way to depend upon the age of the tree. *Habits, &c.:* Grows on similar soils and in similar situations to that previously described.

BROWN-BARKED GUM.—Group *Leiophloiæ* (specimen No. 4).—Bark reddish brown, smooth and slightly mottled. The wood is red and hard. The leaf is from 3 to 4 inches long, and 1 wide, supported on petiole ¾ of an inch in length, alternate, midrib well defined, marginal nerve rather indistinct, veins very numerous, light bluish-green in colour, and very glaucous. *Seed-vessel:* The umbel generally contains seven florets, six of which radiate, and the remainder stand in the centre. On the young vessels the pedicel is short and thick, but as the calyx becomes more developed the pedicel becomes thinner. The peduncle is three-tenths of an inch long. The capsule is about one-third *shorter* than the operculum. The glaucous appearance is very observable on the young seed-vessels. The calyx is generally three but sometimes four celled, and the valves protrude. The flower is of a yellowish-white colour. *Habits, &c.:* Grows generally on patches of poor soil, on otherwise good country; such, for instance, as about porphyritic or elvanite dykes, or outcrops in basaltic formations. In such situations it generally has an undergrowth of dogwood (*Jacksonia scoparia*) and a little grass-tree.

WHITE GUM.—Group *Leiophloiæ* (specimen No. 5.)—Bark smooth and clean, slightly mottled, and at the present time (November) the outer skin hangs in long strips from upper branches. The leaves are generally opposite, many are stem-clasping; the petiole seldom exceeds a quarter of an inch in length. The midrib is well defined and prominent; the marginal nerve and veins are delicate. *Wood:* Light-coloured; heavy but soft; it is not considered durable where exposed to the action of the weather. *Seed-vessels:* The seed-vessels are in umbels of three florets; the operculum is slightly longer than the capsule; the pedicel is one-third as long as the peduncle; some capsules are three and some four-celled, and the valves protrude slightly. *Habits, &c.:* This timber generally grows in rich red basaltic soils which are stony—pisolitic—in company with apple.

PINKED-BARKED GUM.—Group *Leiophloiæ* (specimen No. 6.)—This tree attains a height of from fifty to sixty feet, and diameter from fifteen to twenty inches. The bark is smooth on trunk and branches, and is of a pink colour, and slightly mottled. The wood is hard. *Seed-vessels:* Arranged in umbels of three florets, on short thick pedicel and peduncle one-fourth of an inch long. The operculum is equal in length to the capsule. The calyx is as frequently three as four celled, and the valves protrude. *Leaf:* The leaf is long, and rather thick, and the midrib well defined; the marginal nerve is delicate, and close to edge of leaf. It is frequently covered with small carbuncles about the size of fly-dirt, which gives the leaf a dirty and rough appearance. The midrib is particularly prominent on under side.

Habits, &c.: Frequents basaltic soils, generally, in the warmer parts of New England, in conjunction with box and apple, with occasional native cherry (*Exocarpus cupressiformis*). The tree is of a rather drooping habit, and is not common in New England.

Grey Gum.—Group *Leiophloiæ* (specimen No. 7).—*Bark:* Smooth, blotched dark and light lead colour; very slightly fibrous. Rough for about six feet up trunk. *Wood:* Light-coloured, soft and heavy; fairly durable as fencing material. *Leaf:* Five to six or seven inches long; some alternate and some opposite on same branchlet; petiole half an inch long; midrib prominent and well defined. The marginal nerve is narrow, and two or three well-defined longitudinal veins run parallel to the midrib on either side; the transverse veins form with these a lattice. *Seed-vessels:* Are arranged in umbels of three, four, five, or six florets, standing generally in junction of petiole and twig, on peduncle about one-third of an inch long. Some capsules are tri-valved and some quadri-valved; the valves protrude. The operculum is equal in length to the calyx. *Habits, &c.:* This gum is generally indicative of poor soil; it enters into combination with all the timbers found on granitic formations.

Sally.—Group *Leiophloiæ* (specimen No. 8.)—*Bark:* Rough at butt, but after a height of a few feet, it is smooth and of a dark green colour; it is thinner than the generality of the barks of the genus. *Wood:* The wood is almost useless, except as fuel; it is usually very much eaten by lepidopterous larvæ, and the aborigines frequently cut up small trees for the purpose of obtaining those grubs. *Leaf:* The leaf is alternate. On small shoots from the root it is almost circular and large, but in older trees it is from three to four inches long and about one inch wide, and is lanceolate. It is ribbed very much like the leaf of the *E. coriacea*. *Seed-vessel:* The seed-vessels are about one-tenth of an inch in diameter, and are arranged in umbels of twelve florets, on short pedicels; the peduncle is not more than one-eighth of an inch long, and about one-sixteenth thick. The capsule is three-celled, and the valves sunk, and operculum short. *Habits, &c.:* This tree usually does not exceed a diameter of from eight to twelve inches, but there are numerous specimens which assume a diameter of thirty inches or more. The latter are of rather a drooping habit, and are pretty trees; but the smaller ones appear too straggling to be beautiful. It frequents granitic soils with slight mixture of the detritus from argillaceous rocks, and never grows far from watercourses. It is is very common on the banks of the Henry River, the Mann, and Mitchell Rivers, also on the Severn, above Dundee. All those are cold localities in the most elevated portions of New England, and I have never seen this tree in warmer regions, nor have I seen it growing in the vicinity of river *tea-tree.*

WHITE GUM.—Group *Leiophloiæ* (specimen No. 9).—***Bark:*** Rough at butt for a few feet, but above that is smooth and streaky, showing long light and dark coloured stripes along the bole. *Leaf:* The leaf is from five to eight inches long, with well-defined marginal nerve and protuberant midrib. The veins are very distinct, alternate, but not regularly so: in many cases they are nearly opposite. Petiole, about an inch long, lanceolate. *Wood:* The wood is soft, and is not considered durable. It is generally difficult work with wedges, and, owing to the numerous sap veins, it is not a profitable timber for sawing. It is a bad fuel, and as the tree generally attains a diameter of from two to four feet, it is impossible to clear land by *burning off*, as the heavy logs cannot be kept alight. *Seed-vessel:* The seed-vessels are in umbels of three, four, or five florets, supported on very short pedicels. The peduncle is about three-tenths of an inch long. The capsule is a fifth of an inch in diameter, and is as frequently trivalved as quadrivalved. The valves are slightly protuberant, and a rim runs round the mouth of the calyx. It is about one-third longer than the operculum, and on the younger seed-vessels the pedicel appears to be part of the capsule. *Habits, &c.:* This gum grows chiefly alone, forming open forests. On rich black or red clayey soils it combines with apple, a little acacia, and native cherry, in the colder regions, as about Glen Innes; but the white box mixes largely in the forest on similar soils in warmer climates, as on parts of Strathbogie Run. Those combinations, however, are chiefly on ridges, as the gum forms the prevailing timber on the flats. It also grows on granitic soils, where peppermint mixes with it slightly. On basaltic soils the parasite *Loranthus aurantiacus* (mistletoe) frequently grows on this tree.

YELLOW BOX.—Group *Hemiphloiæ* (specimen No. 10).—There are two species of this tree; one has narrow lanceolate leaves, and the other broad ovate; but the timbers are in every other respect similar. The former, however, appears to have a greater range of soil than the latter, which grows chiefly in argillaceous or granitic formations. They are both distinguished by a bright saffron-coloured undercoating to the bark, which externally is of a reddish-brown colour, rough, but more resembling the common gum bark than that of the box. *Wood:* Hard and tough; very durable as material for fencing; makes good poles and shafts for drays, &c. *Leaf:* 2½ to 4 inches long; midrib stands slightly above surface of the leaf; marginal nerve well defined, alternate; petiole about an inch long, on some of which two leaves grow. *Seed-vessel:* The umbels generally contain seven florets; the peduncle is twice as long as the pedicel; the capsule and operculum are about equal in length, six-celled, and the valves are sunk. *Habits, &c.:* The narrow-

leafed variety enters into combination with almost every kind of timber growing in New England. On all its soils and in every climate it appears to retain its general characteristics with very slight modifications; but the broad-leaved yellow box grows only in the poorer soils in cold localities; they both, however, prefer high and dry ground to flats.

BLACKBUT.—Group *Hemiphloiæ* (specimen No. 11).—The tree resembles the stringy-bark (*E. obliqua*), but the branches are smooth, and the bark is thinner and not quite so fibrous. It appears to partake of the peppermint and stringy-bark. *Wood:* Soft, but fairly durable, free in grain and easily wrought, light in colour. *Leaf:* Opposite and alternate; those on one side of stem are at shorter intervals than those on the other—petioled, and a well defined but not prominent midrib; narrow marginal nerve. *Seed-vessel:* The umbels contain from six to eight florets. The operculum is about two-thirds as long as the calyx; the pedicel is one-sixth of an inch long, and the peduncle one-third of an inch. The valves are not protuberant, and the capsule is usually four-celled. *Habits, &c.:* This blackbut grows generally on granitic soils, but it frequently occurs on the junctions of basaltic soils with those of poorer formation. It combines with stringy-bark, iron-bark, oak, and various kinds of gum.

WHITE BOX.—*E. Hemiphloia;* Group *Hemiphloiæ* (12).—The average height of this tree is from 50 to 70 feet, and the diameter from 18 to 30 inches. The bark is persistent on trunk, and branches smooth. It is light-coloured and slightly fibrous, and is used for covering outbuildings, huts, &c.; but it is much more liable to crack than the bark of the *E. obliqua*, and is not nearly so durable. The *wood* is hard, tough, and durable; it is heavy and close-grained, and is generally difficult to split. It forms an excellent fuel, as it burns readily, throws out great heat, and leaves little ash. The leaves are of a bluish-green colour, slightly glaucous; the midrib is prominent, as also the marginal nerve; and the veins are better defined and further apart than in most other leaves of the genus *Eucalyptus*. The width of the leaf is about 2 inches, and length 5. The petiole seldom exceeds ½ an inch in length. On some trees the leaves appear to be partly alternate and partly opposite. The alternations on all are irregular. Many of the leaves on saplings are nearly circular, and are concave, as though the internal portion of the leaf grew more rapidly than the margin. *Seed-vessels:* The umbels generally contain seven florets, six surrounding, one standing in the centre. The pedicel is very short, and appears to be simply the termination of the calyx. The peduncle is nearly ½ an inch long. The calyx is three times as long as the operculum, and before the latter falls off, the former is marked by four or five prominent ribs. The vessel is four or five celled,

and the valves are deeply sunk. In the fully developed seed-vessels the ribs disappear. The capsule narrows slightly above the valves and then widens out again at the mouth, giving it rather a bell shape. *Habits, &c.:* This tree occurs chiefly on good basaltic soils, in warm regions, similar to those occupied by gum and apple in colder parts of New England.

PEPPERMINT. Group *Rhytiphloiæ* (specimen No. 13).—*Bark:* Rough and wrinkled, similar to that of the apple-tree (*Angophera subvelutina*), but more harsh and solid. Of a dark brown colour, slightly fibrous. *Wood:* Light-coloured, soft, heart reddish-brown. It is generally said to be unfit for use as a timber, except for fuel; but I recently examined some pegs which I put in the ground in June, 1872, and found them to be perfectly sound and good, excepting the sap, which was slightly decayed. The straight bole is very free in the grain, and easily worked. From specimens of this tree about Glen Elgin it appears to be a fast-growing timber, attaining a diameter of 12 to 18 inches, and height of about 50 feet in twenty-five years. *Leaf:* Alternate, lanceolate, from 2½ to 4 inches long (those of saplings are generally longer, being as much as 6 or 8 inches in many cases); dark green colour; midrib well defined; narrow marginal nerve; veins indistinct; petiole half an inch to an inch long. *Seed-vessel:* Small; some trivalved and some quadrivalved on same tree. The umbels contain four, five, or six florets; the peduncle is about one-fourth of an inch long, and is four times as long as the pedicel. One or two florets generally stand in the centre of the umbel, and the valves are slightly protuberant. In most cases the umbel stands in the junction of the leaf-stem with twig. *Habits, &c.:* In the coldest portions of New England this timber grows on basaltic soils, as at Ben Lomond; but it is generally found on granitic soils, or those of an argillaceous formation. On purely granitic formation it forms open forests, but on the others it is generally in combination with yellow box, gum, or stringy-bark.

BOX MESSMATE—Group *Rhytiphloiæ* (specimen No. 14).—This timber appears to partake in some respects the nature of the white box *E. hemiphloia*), and in others that of the New England peppermint. The bark so much resembles that of the box that the tree is frequently mistaken for that timber. It is, however, thicker than box bark, and on being cut with an axe pieces frequently break off with a conchoidal fracture, owing to the large amount of sappy substance which it contains. In the grain it is somewhat like peppermint bark. *Wood:* The wood is soft and light coloured, very much resembling the peppermint; it perhaps contains more moisture. *Leaf:* In the leaf messmate differs from both the peppermint and box. It is generally much longer and more lanceolate than either; some are 10 inches

long; they are alternate, and the petiole is from ¾ to 1 inch long. The veins are similar to those of peppermint. *Seed-vessel:* The seed-vessels, both in appearance and arrangement, are so much like those of the latter timber that I have been unable to detect the difference, if any, between them. In fact the general similarity between the two trees is so great that the only apparent difference is in the bark, and this might be called the white peppermint much more appropriately than box messmate, as there are no real points of similarity between it and the box further than the colour of the bark, and further they belong to different groups in the genus.

BASTARD BOX.—Group *Rhytiphlox.*—*Bark:* Rather lighter in colour than that of peppermint; resembles that of blackbut, but is persistent to branchlets. *Leaf:* in alternate pairs on young trees, but alternate on old ones; dull green with a mottled appearance, which is more observable on the under side of leaf, looking like grease showing through on patches. The leaves are curved, and are about 5 inches long in full-grown trees, but those of saplings exceed that length by 2 or 3 inches. They are lanceolate, and the midrib is prominent; the marginal nerve is narrow and veins well defined; petiole ¾ of an inch long. *Seed-vessel:* Small, ovate, truncated; the calyx is about half as long again as the operculum, and the umbels contain seven florets. *Wood:* Soft and free in grain, easily worked, but will not bear much exposure to the weather. *Habits, &c.:* This timber is never found in rich soils—generally in swampy granitic country, in combination with peppermint, grey gum, banksia, blackbut, and occasional stringy-bark. Ferns mix with the undergrowth. The only soils on which I have seen this timber are formed of the detritus of quartz or red granite.

STRINGY-BARK (*E. obliqua*).—Group *Pachyphloiæ* (specimen No. 16.)—The bark of this tree is fibrous and persistent throughout, and is thick. It is usually used for the purpose of covering outbuildings, and if properly stripped and put on it forms a very good roof, lasting for several years. The wood is easily split or sawn; it is generally straight and free in grain, and the average size of the timber being from thirty to forty-eight inches in diameter, with a straight bole of twenty or thirty feet, without branches, it is much in request by splitters and fencers. The leaves are alternate, and the younger ones are of a bright, glossy, green colour, looking as though varnished; the midrib is well defined, and the marginal nerve narrow, but not clearly marked; the veins form an angle with the midrib of about thirty degrees. *Seed-vessels:* The umbels contain six or more florets, generally with one or two standing in centre; the operculum is short and hemispherical, pedicel short and thick, and the peduncle three-tenths of an inch long; the capsule is slightly contracted at

orifice, it is trivalved, and the valves protrude slightly. *Habits, &c.:* This tree grows in all classes of soil except black alluvial; on the red friable soils of the basaltic formations about Vegetable Creek it is a large tree, frequently exceeding four feet in diameter; on those soils it is always accompanied with wild hop (*Dodonea*) and wattle (*Acacia*); on granite and elvanite soils its undergrowth is generally saplings of stringy-bark; it is sometimes, however, on those soils accompanied by wattle; its timber combinations are iron-bark and various kinds of gum.

YELLOW IRON-BARK.—Group *Schizophloiæ* (specimen No. 17).—The bark of this tree is much less wrinkled and the wrinkles are narrower than that previously described, and it has a rich yellow sap-coating under. The wrinkles form diamond shapes. In the larger trees the bark is smoother than in the smaller ones. The wood is hard and tough; the heart reddish brown. It is a durable wood, and well suited for poles and shafts of drays. *Leaf:* Lanceolate; midrib is prominent on the under side, as are also the marginal nerves; bluish-green colour, and the petiole is about half an inch long, alternate. *Seed-vessel:* The umbels contain generally six florets, supported on long, thin, and pliant pedicels nearly half an inch long; they droop. The operculum is much shorter than the calyx, which contracts at the orifice. The capsule is six-celled, and the valves are sunk; the orifice is surrounded by a well-defined lip; the peduncle is about a quarter of an inch long, and is thin and tough. *Habits, &c.:* Frequents poor granitic soils; scrub oak generally grows in company with it, also stringy-bark, blackbut, and yellow box; the blue gum also grows on this soil. In swampy patches the plant known as "bottle-weed," a flesh-eater, *Drosera peltata* of botanists, occurs.

IRON-BARK.—Group *Schizophloiæ* (specimen No. 18).—This tree generally inhabits soil of a very poor character. On New England it grows on elvanite ridges most frequently; not often on purely granitic country, but frequently about the junction of granite with basalt. The bark is very thick and hard; the creases are deep and irregular; its general colour is dark brownish black, but between the creases it is reddish. The wood is very hard and durable. There is more evenness in size between the leaves of young and old trees than is usual between those of most other species of the genus *Eucalyptus*; they are about three inches long, and half-an-inch wide, of a bluish-green colour; dark and sombre looking foliage. They are alternate in pairs, the intervals between the pairs on one side of the twig being shorter than those of the other; after two or three alternations one pair is opposite. The petiole is three-tenths of an inch long, and the midrib is well defined, but does not stand above the plain of the leaf; the veins are delicate and regular, but the marginal nerve is not well defined. *Seed-vessel:* The umbel generally contains seven florets, and there are frequently two or three

umbels on the same stem. The operculum is half as long as the calyx; the pedicel and calyx are of equal length, and the peduncle twice as long as the capsule. *Habits, &c.:* In rocky elvanite land this iron-bark mixes with yellow box, red gum, and stringy-bark, with a little stunted apple. The undergrowths are chiefly *Jacksonia scoparia* (dogwood) a species of blackwattle, and numerous small shrubs—five-corner, geebung, &c.

Stringy-bark.—Group *Pachyphloiæ* (specimen No. 19).—This tree differs from that previously described (specimen No. 16) in the leaf and seed-vessel more than in anything else. The leaf is of a dark-green colour, and the young ones lack the bright glossy appearance of those on the former species. The petiole is half an inch long, and the midrib well defined and slightly prominent. The operculum is two-thirds as long as the capsule, and the pedicel is short and very thick. The peduncle is about four-tenths of an inch long, and is also thick. The leaves and florets frequently appear to be covered with a dirty black substance resembling soot. Usually there are five florets in the umbel, some of which are bigger than others, and finish flowering before the others are open. Some of the fully-developed seed-vessels attain a large size; they are three-celled, and the valves form an upper hemisphere to the calyx, from which it is divided by a broad creased band. *Habits, &c.:* This tree is generally found in rocky elvanite soils, where the rock approaches in its granular character to the nature of sandstone. It combines with all timbers peculiar to this class of soil.

Bastard Yellow-jacket.—Group *Rhytiphloiæ* (specimen No. 20).—This tree is very similar in bark and wood to the white box (*E. hemiphloia*), but the leaf is similar to that of the yellow box. It is of exactly the same size and appearance as that of that tree, but the petiole is much shorter, being only half an inch long. The seed-vessel is in umbels of three, four, five, or six florets. The pedicel is short, and the peduncle one-fourth of an inch long. The operculum is very small, and is one-third as long as the calyx, and almost flat. In its young state, before parting with the operculum, the seed-vessel is not more than one-sixteenth of an inch in diameter; after flowering it is about one-tenth. The calyx is sometimes three and sometimes four celled, and the valves do not protrude. Many of the leaves of this tree are affected by a disease which causes gnarled lumps on them; in the centre of these lumps is a small white insect, a species of grub, probably the larvæ of a small fly, which appears to be numerous about many specimens of the tree, all of which were affected with the disease. The excrescences may be caused by the larvæ. *Habits, &c.:* Frequents granitic and elvanite soils in company with box, messmate, stringy-bark, &c.

On Dromornis Australis (Owen), a new Fossil Bird of Australia.

By the Rev. W. B. Clarke, M.A., F.R.S., &c.

[*Read before the Royal Society of N.S.W.*, 6 *June*, 1877.]

In the year 1869 a letter of mine appeared in the *Sydney Morning Herald* on a subject of some interest to Australian naturalists. (See Appendix No. 2.)

A discovery had recently been made of the fossilised femur of a bird resting on a block of granite, at a depth of 180 feet in the superficial beds of Peak Downs, in Queensland, about latitude 22° 40′ S.

This femur was submitted to examination by the Curator of the Australian Museum, and was compared by him and myself with New Zealand specimens of femora of the genus *Dinornis*. We came to the conclusion that the bone belonged to a species of Moa. (See Appendix No. 1.)

This was afterwards stated by me in a communication to the *Geological Magazine* (vol. vi, p. 283), in which I dwelt, perhaps prematurely, on the supposed evidence offered by this bone of a former connection between New Zealand and Australia, inasmuch as *flightless* birds could not have passed so wide an ocean as intervenes between these countries. In my "*Remarks on the Sedimentary Formations of New South Wales*," I have considered that connection in another light. (See Appendix No. 3.)

Professor Owen, to whom a cast of the bone was sent (the original still remaining in the Australian Museum), informed me that it had some characteristics agreeing with those of *Dinornis*, but that others led to the determination that it did not belong to the Moas, having nearer relation to the Emu.

Since that time, in the Transactions of the Zoological Society, the learned Professor published a description and figures of the bone, with comparisons which no one was better able to make than himself. (See Appendix No. 4.)

In that memoir he says: "Of the femora of *Dinornis*, I have selected that of *Din. elephantopus* (Transactions Zoological Society, vol. iv, p. 149, pl. 43, fig. 1) as nearest to the present fossil in regard to length, 13 inches; the breadth of the shaft is the same, or in the largest examples of *D. elephantopus* exceeds only by 2 lines."

Here we have some justification of the opinion I had ventured to express. But, in conclusion of his review, he adds: "I infer that in its essential characters this femur resembles more that bone in the Emu than in the Moa, and that the characters in which it more resembles *Dinornis* are concomitant with and related to the more general robustness of the bone, from which we may infer that the species manifested dinornithic strength and proportions of the hind limbs, combined with characters of closer affinity to the existing smaller, more slender-limbed, and swifter wingless bird peculiar to the Australian continent.

"From the proportions of the femora of *Dinornis* I infer also that those of the tibia and metatarse would be longer and more slender than in *Dinornis elephantopus*, and in a greater degree than is the case with the femur. Consequently, the stature of *Dromornis* would be greater in proportion to the solitary bone by which we know it than is that of the *Dinornis elephantopus*. We may, therefore, have a comfortable assurance that it indicates the former existence in Australia of a bird nearly of the stature of the ostrich, but with relatively shorter and stronger hind limbs. * * * * From the general analogy, not unfrequently pointed out, between the recent animal and vegetable forms of the Australian continent and the extinct ones of the European oolitic beds, together with the massive mineralized condition of the ornithic and mammalian fossils found deep in the enormous superficial accumulations of drift and trappean alluvium, we are led to surmise that Australia, or parts of that continent, have not been subject to the frequent movements by which the earth's crust has been modified in the European continent, but that it may have been subject exclusively to the subaerial conditions of change from the period of the oolitic deposits in our hemisphere. Thus the *Dromornis* of Queensland may have been contemporary with the impressors of the ornithicnites of Connecticut."

These remarks of the illustrious palæontologist are not without bearing on other points of inquiry on which I have ventured to speculate elsewhere.

But, as my object in this communication is to show what advance has been made in the history of *Dromornis*, I must go further into the subject.

Since 1869 I have been on the look out for additional evidence as to *Dromornis*, but not till 1876 did I meet with any.

In January of that year, when at Goree, near Mudgee, I received intimation that a large bone had been disinterred from a depth of 200 feet at the Canadian Gold Lead. On going that day, with my friend Mr. Lord, I found the bone in the possession of Mr. Deitz, a former correspondent of mine on mineral matters: but not (as I suspected from the first account of it

given to me) a femur or other limb bone of *Diprotodon*, but a fragment of the *pelvis* of a bird, which was considered by some of the diggers to be the head of some animal. This fragment was placed in my hands for examination. On arriving in Sydney I took it to the Museum for comparison, and came to the conclusion that it had also resemblance to *Dinornis*, but was not the pelvis of the true Emu.

Photographs of it were afterwards sent by me to Professor Owen, and a model of it was made by the taxidermist of the Museum for that institution, from the Trustees of which I received a copy.

The original pelvis I sent on to Professor Owen by Captain Pile, of the "Patriarch." The latter had not reached its destination on the 31st January, 1877, the date of the Professor's last letter to me; but in a former letter, under date of August 1, 1876, he wrote thus:—"I have to-day received your note of 9th June, with the accompanying photographs. I make out the left acetabulum and surrounding parts of the pelvis of a bird about the size of *Dinornis ingens*, but differing in certain proportions of parts."

On the 5th December he writes: "As to the big wingless bird, the only bone yielding information testified against its Moa-ship. Your later pelvic fragment (in the photo.) does not speak decidedly *pro* or *con*. This gossiping commencement will keep till I receive your kindly transmitted box, when its contents will have my best attention, and the results will be annexed."

On 31st January he adds:—"I will not longer defer posting the previous note with this supplement, because, since writing on 5th December, I have had the lower portion of a *tibia*, found in the Gambier Ranges, sent from South Australia. It corresponds in size and condition of petrifaction with the femur figured in the paper, and being a more decisively characteristic bone than that, as both are, when compared with a portion of pelvis, I have sent a description of it, with accompanying drawings, to our Zoological Society. This bone determines beyond question the fact of the former existence in the Australias of a wingless or flightless bird of the size of *Dinornis elephantopus*, but of a genus nearer akin to *Casuarius* and *Dromarius*. The probabilities are that the femur from the breccia-cave of Wellington Valley, that described, your portion of pelvis and the South Australian tibia, are parts of the same genus if not species. It is more convenient and conducive to progress to record them, until proof to the contrary be had, as parts of *Dromornis Australis*. And we now have indications of the former extensive range of the bird on your great continent."

The bone from Wellington Valley was mentioned in the "Memoir on the Queensland Femur," and was described and

figured in the "Palæontological Appendix" to Mitchell's work of 1838 (pl. 32, figs. 12-13) :—"The length of that bone was thirteen inches; the breadth of the middle of the shaft was not quite three inches."

Whether any further communication from the distinguished Professor alter or confirm his present determination remains to be seen. But of this most interesting fact we may be assured that, in addition to the gigantic marsupials of which the public are generally aware, there also existed in past days over a wide region of Australia a gigantic bird, or birds, of which we shall soon know more; and then we shall see fresh proof of the extraordinary fact which I noticed in connection with the Queensland femur (Address to Royal Society, N. S. W., 1870), that in all the tracts of land in the southern hemisphere, insulated or continental, flightless birds have roamed over extensive regions, and that, as in New Zealand, so in Australia, there were ornithic giants.

Whether, therefore, the inquiry be respecting *Dinornis* or *Dromornis*, Australia comes into the category with the *Moa* of New Zealand, the *Epiornis* of Madagascar, the *Dodo* of Mauritius, and the *Solitaire* of Rodriguez, all of which are now extinct.

In closing this brief account of the progress of inquiry as to an Australian fossil flightless bird, which I hope will have the effect of inducing researches by others, I cannot resist pointing out, in the words of Professor Owen, that there is another of the giants of the past of which more is required to be known. He says, in concluding his last letter to me—"How strange it is that no tooth, or portion of jaw, or fragment of skull of the contemporary great land lizard (*Megalemia*) comes to hand. Vertebræ I receive from time to time, with their evidences of extinct mammals. But there must be an end in finite working, and I am therefore sending the 'Researches on the Fossil Mammals of Australia' to the binder."

I may here conclude with an earnest request that gold-diggers, and others who work in deep soils and river banks, or in caverns, will preserve and consign for scientific examination all fragments as well as whole bones of fossilized animals, or birds, or reptiles. They cannot confer a greater favour on Palæontology than in acting on this suggestion, as hundreds of instances are known in which valuable relics of the kind have been mutilated and thrown away by the discoverers, as having no commercial value to themselves. It is highly probable that the gold leads in the neighbourhood of Gulgong, Home Rule, and Mudgee will furnish some interesting additions to the example now treated of, as I saw many fragments of marsupial bones, and some I considered bird bones were given to me at the Canadian; and since, a portion of the jaw of a marsupial has been found in Mr. Lowe's paddock, and this has kindly been forwarded to me by him.

APPENDIX.

No. 1.

To the Editor of the Herald.

Sir,—The Rev. W. B. Clarke called at the Museum a few nights ago with the "shankbone" of some gigantic animal discovered 180 feet below the surface, in the neighbourhood of Rockhampton (I think). We compared the fossil with some of the Museum specimens, but as Mr. Clarke was otherwise engaged, the bone was left with me for further determination. I informed Mr. Clarke the next morning that it was the bone of a gigantic bird allied to the flightless Moas of New Zealand.

I must confess that I have never seen or heard of the remains of a *Dinornis* found in Australia; and when I suggested to Mr. Clarke that it could not well be any other than a bird bone, I was almost afraid that I had made a mistake, owing to the solid appearance of the specimen under examination.

Thanks to the splendid collection presented to the Museum by Dr. Haast, F.R.S., the well known New Zealand geologist, I was enabled to convince myself that the bone is the right femur of a species of *Dinornis*, which will be fully described hereafter.

I am, &c.,

May 18th, 1869. GERARD KREFFT.

No. 2.

DINORNIS.

To the Editor of the Herald.

Sir,—I am glad Mr. Krefft has announced the femur of *Dinornis* in this day's *Herald*, as too many of our discoveries are first made known in England.

The bone in question is a very important discovery. *But it is not mine;* it was brought to me by a gentleman who states that it was found in sinking a well on Peak Downs, between the heads of Theresa Creek and Lord's Table Mountain.

Two or three years since I forwarded to Professor Huxley, for examination, some bones of a *Trionyx* and teeth of Crocodile found in Crinum Creek. That district is therefore of a very interesting character.

The *Dinornis* bone was found under 30 feet of alluvial clay and mud, covering 150 feet of drift, and rested on what *is said to have been a granite rock*, which, however, was pierced in the hope of finding water, but of which only a little was reached.

I am enabled to state, from having broken up many hundred pebbles and boulders, that, besides any Tertiary deposits in that region, there is an enormous amount of fragments, some only

partially rounded, of Silurian, Carboniferous, and Secondary ages, as well as those belonging to local igneous rocks, among which I detected two of an unusual character containing gold, which was proved on analysis at the Mint. These Pleistocene pebbles led to Mr. Henley's announcement of what he called his "Tertiary river," which was explained differently by me in a correspondence I had on the subject with the late Gold Commissioner at Clermont.

The *Dinornis* bone leads to the inference that views long ago expressed by me of the former connection of New Zealand with this country were correct.

But I am bound to say that this bone is not the first evidence of the existence of birds in Australia in Pleistocene times; for on reference to the Catalogue of Industrial Products of New South Wales, exhibited in the Australian Museum in November, 1854, and afterwards in Paris, you will find enumerated in the list of geological specimens exhibited by myself on those occasions, among other Quaternary relics, the following:—"No. 49, Osseous Breccia Bird Bones (Coodradigbee Cavern)." Thus New South Wales has preceded Queensland in the discovery of bird bones of Pleistocene age.

W. B. CLARKE.

St. Leonards, 19th May, 1869.

P.S.—The *Dinornis* bone is so completely filled in and mineralised by calc spar and iron pyrites as to present a solid mass, resembling more the condition of a reptilian than an ornithic relic; but the characters which I hastily compared with skeletons of birds, in company of Mr. Krefft, and afterwards, more leisurely, with Owen's figures and descriptions of *Dinornis*, lead me to confirm Mr. Krefft's opinion; and as I have since compared the bone with the bones of *Dinornis* in the Museum, there is no doubt as to the genus.

W.B.C.

No. 3.

DINORNIS AN AUSTRALIAN GENUS.

To the Editor of the Geological Magazine.

Sir,—It will be interesting to your readers to know that evidence has at length been discovered of the former existence in Continental Australia of birds of the Pleistocene genus *Dinornis*.

A short time since a well was dug in that part of the Peak Downs in Queensland (about lat. 22° 40′ S.) between Lord's Table Mountain and the head of Theresa Creek, near the track from Clermont to Broad Sound.

The well passed through 30 feet of black trappean alluvial soil, so common in Australia, which rested on 150 feet of drift pebbles

and boulders, on one of which (at that depth) rested a short thick femur, so filled in with mineral matter, calc spar, and iron pyrites, as to give the internal structure more the appearance of a reptilian than an ornithic bone. I have never yet seen any bone in Australia so much mineralized and yet retaining its distinctive osseous features. When placed in my hands it had been already broken in two, just as a bird's bones would be likely to break. But besides this, there are two crushed-in fractures of ancient date, which have broken in the surface of the bone, and if not made in the life-time of the bird, were probably made by the violence of the heavy drift in which it was found.

I had an opportunity of comparing it hastily at the Australian Museum, in company of Mr. Gerard Krefft, our able Curator, and was convinced of its being a bird bone, allied to *Dinornis*, to which opinion I was afterwards led by reference to the writings of Professor Owen. Since then Mr. Krefft has compared it with a collection sent over from New Zealand, by Dr. Haast, and has been enabled to determine it to be a bone belonging to *Dinornis*.

I take advantage of the departure of the mail to-morrow to announce this fact, waiting for a further account of the specimen from Mr. Krefft.

The Peak Downs were discovered by Leichhardt, in his famous expedition to Port Essington in 1845.

Since then the district has been traversed by Mr. Gregory, to whose journal as well as to that of Leichhardt your readers are referred.

The Peak Downs are now settled, and a considerable population has been digging gold on Theresa Creek and in other places, and mining for copper has made advances to the westward at Mount Drummond.

Some time since, my attention was invited to a statement made by the Gold Commissioner there, to the effect that a "*Tertiary river*" had been discovered, and I was requested to examine the facts alleged. On breaking up a vast amount of the pebbles and boulders said to have been found in this "Tertiary river" I discovered that there was no clear evidence of anything that could be called Tertiary, but that they were pebbles of probably Quaternary accumulation, consisting of Silurian, Carboniferous, and Secondary rocks, with the igneous rocks of the neighbourhood, which latter may be in part of Tertiary age.

In some of the creeks running more to the south-eastward from the Peak Downs, and like Theresa Creek, belonging to the Mackenzie River system (*e.g.* Crinum Creek) occur bones of *Trionyx* and Crocodile. A year or two ago I forwarded some of these to my friend Professor Huxley, whose determination I have not yet received.

The naked fact of the discovery of *Dinornis* in this country is of some value as to geological inferences.

I may add, in conclusion, that I look forward to further discoveries in the vast accumulations of drift that encumber some of the localities in the neighbourhood of the rivers watering the Leichhardt district, where, among other relics, are those of the Carboniferous formation, which now presents only the wreck of a mass of strata that once must have been partly continuous over an area comprising several degrees of latitude and longitude on one side or other of the Tropic of Capricorn.

W. B. CLARKE, F.G.S.

St. Leonards, New South Wales, 19th May, 1869.

P.S.—I have omitted to mention that, in the collection I exhibited at Paris in 1865, No. 49 consisted of *osseous breccia* (bird bones) from the Coodradigbee Cavern in New South Wales. So *Dinornis*, though new, is not the first of the order.

No. 4.

EXTRACT from the "Transactions of the Zoological Society of London"—vol. viii, part vi.

On DINORNIS (Part xix): *containing a description of Femur indicative of a new genus of large Wingless Bird*, DROMORNIS AUSTRALIS, *Owen*, *from a post-tertiary deposit in Queensland, Australia.* Read June 4th, 1872.

[Plates LXII and LXIII.]

In 1836 Sir Thomas Mitchell, F.G.S., Surveyor General of Australia, discovered in the breccia-cave of Wellington Valley a femur, wanting the lower end, mutilated, and incrusted with the red stalagmite of the cave, which I determined to belong to a large bird, probably, from its size, struthious or brevi-pennate, but not presenting characters which, at that time, justified me in suggesting closer affinities.

Three views of this fossil, of rather less than half the natural size, formed the subject of pl. 32, figs. 12, 13, of my "Palæontological Appendix" to Mitchell's work.

The length of this fossil was 13 inches; the breadth of the middle of the shaft was not quite 3 inches.

In 1869, the Rev. W. B. Clarke, F.G.S., made known the interesting discovery of a femur, nearly 12 inches in length, during the digging of a well at Peak Downs, in Queensland.

The well was sunk through 30 feet of the black trappean alluvial soil common in that part of Australia, and then through 150 feet of drift pebbles and boulders, on one of which boulders ("at that depth," 150?) rested a short thick femur, so filled

with mineral matter (calc spar and iron pyrites) as to give the internal structure more the appearance of a reptilian than an ornithic bone.

Mr. Clarke submitted this fossil to the able Curator of the Australian Museum, Sydney, and states that "Mr. Krefft had compared it with a collection sent over from New Zealand by Dr. Haast, and has been enabled to determine it to be a bone belonging to *Dinornis*. The communication is accordingly headed "*Dinornis*, an Australian genus."

So exceptional an extension of New Zealand forms of life to the Australian continent greatly added to my desire of further and more intimate acquaintance with this *second* evidence of a large extinct Australian bird, more especially as the femora of *Dinornis* received from New Zealand subsequently to the publication of Mitchell's work led me to perceive, from the antero-posterior compression of the shaft and the sessile position of the head of the femur from the Wellington Valley cavern, that it resembled that bone in the Emu rather than in the *Dinornis*."

My wishes on this point, as others connected with the palæontology of Australia, met with a prompt and hearty response. The Trustees of the Australian Museum directed the unique bird's bone to be moulded, and they forwarded to me a plaster cast.

Mr. Krefft was so good as to have three photographs taken of the fossil: one showing the back view of the bone, three-fifths of the natural size; the two others, the front views of the proximal and distant halves of the bone, of very nearly the natural size.

Part V.

On the Sphenoid, Cranial Bones, Operculum, and supposed Ear-bones of Ctenodus.

By W. J. Barkas, M.R.C.S.E., L.R.C.P.L.

[*Read before the Royal Society of N.S.W.*, 6 *June*, 1877.]

Leaving the bones that enter into the formation of that portion of the buccal cavity connected with the teeth, we come next to those that enclose the cranial cavity and that enter into the remaining portions of the endo-skeleton. Of these bones a few are yet absent from our cabinets; they are principally head-bones, if not altogether so, for it is probable that all the other parts of the endo-skeleton not in our possession were cartilaginous, and therefore incapable of fossilization; among the latter are the vertebræ. Not any vertebral segments have been connected satisfactorily with *Ctenodus*, in this respect *Ctenodus* seemingly agreeing with *Ceratodus*, the vertebræ of which are cartilaginous. If this fossil fish had possessed a bony spine we should certainly have discovered numbers of the segments, both in conjunction with undoubted bones of *Ctenodus* and either single or in masses, for other portions of the osseous system are comparatively abundant, the teeth, for example; yet for every tooth found there ought to have been imbedded in the shale, at the lowest computation, from eight to twelve vertebræ. Another fact tends to prove the cartilaginous nature of the spine of *Ctenodus*; such fishes as *Rhizodopsis*, *Megalichthys*, *Strepsodus*, *Cœlacanthus*, *Archichthys*, all of which are found in the same coal shales, possessed osseous vertebræ, and which having become preserved in the shale, are now obtained just as frequently as any other bones of those fishes. This absence of osseous vertebral segments in *Ctenodus* and *Ceratodus* at once removes these fishes from the *Ctenodipterines* of Eichwald, but *Dipterus* may still pertain to that group, as its vertebræ are osseous.

The sphenoid or basal bone occupies the space in the base of the cranium caused by the divergence of the pterygo-palatine bones as they proceed posteriorly from the symphysis. Judging from the great length of the bone, I conjecture it must have projected much beyond the floor of the cranium proper, much further than this bone does in *Dipterus* or even in *Ceratodus*, in which it reaches as far back as the third neural spine. In the case of *Ctenodus* the posterior projection is very greatly produced, much more so than in *Ceratodus*, while in *Dipterus* it extends very little

further than the extremities of the pterygo-palatine bones. Although the basal bone of *Ctenodus* is of much greater length than the sphenoid of *Ceratodus*, it possesses the same fundamental conformation. This bone was first described by Messrs. Hancock & Atthey in the "Transactions" I have so often had occasion to refer to, in a paper entitled "A few remarks on *Dipterus* and *Ctenodus*, and on their relationship to *Ceratodus Forsteri*, Krefft"; but they did not give any illustrations. Mr. T. P. Barkas, F.G.S., in his "Coal Measure Palæontology," merely mentions the fact of some sphenoid bones being in his possession, and portrays one in an excellent lithograph. Messrs. Hancock & Atthey thus describe the bone in the paper mentioned above:—"The sphenoid is a much elongated depressed bone, with a wide lozenge-formed expansion near the anterior extremity; in other words, the posterior angle of the lozenge-formed expansion is much produced, while the anterior angle is only slightly produced. The frontal portion (the pre-sphenoid) is rounded, inclining to conical at the extremity, and fits in between the divergent bones that support the dental plates. The lozenge-formed expansion lies partly behind these bones; and the elongated posterior extension (the basi-sphenoid) is continued for a considerable distance further back, in the large species for nearly five inches. * * * The basi-sphenoid at its junction with the lozenge-formed expansion is usually thick and nearly circular; elsewhere it is flattened." A specimen in my cabinet differs slightly from the above description, in that the anterior projection is rounded, not showing any tendency towards a conical contour; nor does a transverse section of the basi-sphenoid tend to a circular form near its junction with the lozenge, as at that point it rises into a high crest on the buccal surface. I notice also in my specimen a point not mentioned by Messrs. Hancock & Atthey, and it is that on each edge just posterior to the lateral swelling in centre of the basi-sphenoid is a small oval depression like the depression of an articulation, and I am inclined to consider that it is the remains of a joint between this bone and the first rib, just as we see is the case in *Ceratodus*. I am not aware that the rib has ever been discovered *in situ*, but analogy would certainly lead one to infer that my conjecture is correct. For comparison with the above account, I give Günther's brief description of the basal bone of *Ceratodus*:—"It is lance-head shaped, broadest between the tympanic pedicles, tapering in front, and still more behind, filling out the entire space between the pterygo-palatines, and extending backwards far beyond the commencement of the vertebral column, to the level of the third neural spine. It is a thin bone, except in the middle of its length, where large medullary cavities are imbedded." It is perhaps unnecessary for me to add that the greater posterior extension of

the sphenoid of *Ctenodus* shows that the head of that fish must have had a diameter antero-posteriorly much beyond that of *Ceratodus* and *Dipterus*. Of the remaining head-bones not much is known satisfactorily, as all the heads that have been disinterred are much crushed and distorted. Occasionally detached bones are discovered, but generally they are procured in masses of two to six bones anchylosed together, the sutures, however, remaining perfectly distinct. Mr. Barkas, in his "Coal Measure Palæontology," devotes a short chapter to three groups of cranial bones in his possession, in which he remarks:—"The external bony plates which covered the probably cartilaginous skulls of *Ctenodus*, *Dipterus*, *Asterolepis*, *Osteolepis*, *Coccosteus*, *Diplopterus*, and other Devonian and Carboniferous Fishes, bear but a slight resemblance to the arrangement of the true internal cranial bones which form the skull proper of osseous fishes. All attempts to classify them, therefore, can only be approximate; and, following as closely as I am able the plan of classification furnished by Prof. Huxley, I venture to indicate the following homological relationships of the three groups of bony plates already referred to, * * and provisionally suggest the following as their probable interpretation:—Supra-occipital, frontal, epiotic, parietal, post-frontal, supra-temporal; squamosal; post-orbital. The arrangements of the cranial plates of *Coccosteus*, *Osteolepis*, *Diplopterus*, *Dipterus*, and *Asterolepis*, may be seen by referring to pages 46 to 74, Hugh Miller's 'Footprints of the Creator,' by comparing which with the figures of the cranial plates of *Ctenodus*, now for the first time figured and published, it will be seen that there is considerable difference in the arrangements of the bones; the chief and most characteristic difference being the approximation of the occipital and frontal bones, the singleness of the frontal, and the separation of the parietal bones by having the occipital bone wedged in between them. The cranial plates of *Dipterus* perhaps most closely approach those of *Ctenodus*, but in *Dipterus* the parietals are between the occipital and frontal, and are in close contact with each other, while in *Ctenodus* the parietals are separated from each other by the width of the broad occipital plate." The groups of cranial bones mentioned above are illustrated in the "atlas" accompanying the above work. Mr. Atthey mentions that he has been able to distinguish among his specimens the anterior, median, and external occipitals, parietals, and three posterior lateral or skin bones, and he adds that these bones in *C. tuberculatus* "so closely resemble the same bones in *Dipterus* that they might be taken to belong to a gigantic specimen of that genus"; but on this point it will be noticed that Mr. Barkas, in the quotation I gave from his work, points out a marked difference between these two fishes in the arrangement of the occipital and frontal bones, *Dipterus* having the parietals between those

bones, while in *Ctenodus* they are on each side of the occipital. Mr. Atthey may be correct enough in his statement, if I may judge from the names he gives, for the bones he has had the opportunity of examining are posterior to those described by Mr. Barkas. The whole of this subject, however, is so imperfectly known, each anatomist seemingly giving new names to the cranial bones, that it may possibly be that Mr. Atthey and Mr. Barkas are both often referring to the same bones, Mr. Atthey taking the nomenclature of Pander, Mr. Barkas that of Huxley.

On a slab in my possession are two masses of head-bones, one on each surface, as though they had originally been united in one shield, and before fossilization some catastrophe had happened and bent the roof of the skull through the middle, but whether this is so or not, the two masses are certainly head-bones of *Ctenodus*, as they present the pitted and granular appearance usually seen in such bones. What bones are present in these two pieces of the cranial shield I am not in a position to say positively, for there has not been any distinct account given of the cranial bones of *Ctenodus*, and they do not resemble any bones in the *Ceratodus*' skull, but this latter fact may arise from the fragmentary nature of my specimens. By comparing one of my specimens with Mr. Barkas's figure pl. x, fig. 244, however, I conjecture the bones forming the group to be the frontal, supra-occipital, median occipital, epiotic, parietal. In another fragment of a cranium there is a bone with an arrow-head projection which may correspond with Mr. Atthey's occipital, which is thus described: "In the latter (*C. tuberculatus*) it (the frontal border) projects and has a wedge-shaped process in the centre." If this be so, then we may translate this group as being composed of the supra-occipital, epiotic, and median occipitals. It must not be forgotten that in these names I am only employing conjecture.

In all the crania that have been examined the outer surface of the bones present a pitted and granular appearance, and are also somewhat glistening; in some of the bones the pitting is not so distinct as usual, but long depressed arborescent streaks are plentiful which radiate from a boss situated near the centre of the bone, the surface thus having a peculiar radiated aspect, and gives one the impression of a cartilage having become fossilized as ossification was advancing; a microscopical examination, however, shows, that the bone is osseous throughout. The bones are always small compared with the size of the cranium; vary much in contour, but in size they are pretty uniform, no bone predominating much over the others; they unite with each other by imbricated sutures that have apparently become anchylosed early in life to form a compact shield.

The opercula are of comparatively frequent occurrence in the shales of the Northumberland coal measures. They vary greatly

in size, Mr. T. P. Barkas figuring one in his "Atlas of Carboniferous Fossils" that measures 6¼ inches in one diameter and 5½ inches in the other; he also gives a lithograph of a section of another, 1¼ inch and 1 inch in its longest and shortest diameters respectively. Mr. Atthey owns an operculum of *C. elegans* which is only 5-16ths of an inch in its longest diameter. I have in my possession two opercula, one being 3½ inches in its longest diameter, and the other 2 inches. The sizes of these opercula being so variable necessarily leads us to infer that they pertain to different species of this genus, and in this conjecture we are strengthened by the facts that these bones vary also in their conformation and thickness; my observations tending to prove that the larger the operculum, the nearer it approaches to the circular form and the thicker is the plate. The large opercle in my possession does not bear much resemblance to the same bone in *Ceratodus*, but the smaller one has a great similarity to the plate figured by Günther, "Philosophical Transactions" for 1871, pl. xxxv, fig. 1 *h*.

The literature concerning this bone is not large, Mr. T. P. Barkas describing isolated specimens in the "English Mechanic" and "Scientific Opinion." Messrs. Hancock and Atthey, in their paper on "*Dipterus* and *Ctenodus*," refer to it at some length, and in the following words: "The opercula resemble those of *Dipterus;* they are large, stout, slightly convex, irregularly circular plates, with one side of the margin a little flattened, and slightly produced at each end of the flattened space; the surface is punctate and granular like the cranial bones. We possess six or seven different forms of these gill-covers, two of which have been identified as belonging to *C. elegans* and *C. obliquus* respectively." The only illustrations that have been published are those of Mr. Barkas, to which I have already referred.

Before entering upon a description of the bones of the body of *Ctenodus*, I must refer to certain bodies that are supposed by Mr. T. P. Barkas to be otolites, and, as he considers probable, otolites of *Ctenodus*. Concerning these bodies I do not feel in a position to commit myself to an opinion as to their nature, although I have examined numbers of them both externally and internally, as I have never had an opportunity of investigating the structure of an undoubted ear-bone of either a living or a fossil fish. I shall, therefore, allow Mr. Barkas to speak in his own words, which I extract from his "Coal Measure Palæontology":—

"Fig. 175 represents a rare and little understood fossil, probably an otolite or ear-bone of a fish. Fig. 176, a transparent microscopic section of the same fossil, illuminated by transmitted light, and magnified 20 diameters; showing the minute structure of the preparation. In 'Scientific Opinion,' vol. ii, p. 173, after stating that I had five specimens of this fossil, I said, 'In external appearance these specimens closely resemble each other, but,

when mounting a specimen a few hours ago, I found that, in structure, it very materially differed from that I had previously prepared for the microscope. The first supposed otolite which I mounted was beautifully transparent, of a deep lake colour, and appeared, when examined by objectives of high power, to be perfectly structureless. The present otolite, like that previously described, was very hard and difficult to reduce to a proper degree of thinness. Its structure is marked and peculiar, and its colour is a very deep red. Whatever these bones may be, they differ very materially in colour and structure, and probably belong to fishes of a different genera, or, at least, of different species. The last specimen, when under microscopic examination, is seen to be extensively permeated or covered by irregular nodular twisted lines, resembling to some extent the attached frustules of *Diatoma vulgare*, or the stems and polype cups of the smaller forms of *Sertularia*. Among those masses of nodular lines are scattered a number of small circular discs of various degrees of transparency.'

"The fossil remains in the Coal Measures are generally somewhat heterogeneously mixed together, and, in some cases, the slabs of shale contain remains that evidently belonged to one fish. When that is the case, somewhat safe inferences may be drawn as to the leading characteristics of the fish the remains of which have been preserved. Upon a slab of shale in my possession there are a large mandibular tooth and various head-bones of *Ctenodus*, and associated with them is a very excellent specimen of a supposed otolite. If any inference is to be drawn from this association of fossils, it is that the otolite in question belonged to a *Ctenodus*, and that it is not improbable, as, unlike *Gyracanthus*, *Diplodus*, and many other coal-measure fishes, the *Ctenodi* had ossified head-bones, opercula, and ribs, and, in all probability, were possessed of otolites.

"I have in my possession upwards of 200 upper and lower compound teeth of various species of *Ctenodus*. It is improbable that small bones, such as the otolites of the smaller *Ctenodi*, should be found, and the discovery of the otolites of the larger *Ctenodi* would be much less frequent than the discovery of their teeth, because each fish possessed four, or it may be eight teeth, and would only possess two otolites. Besides, the teeth are large and easily recognized, and the otolites may easily be overlooked in the process of breaking and examining the shale. The argument of the smallness of the number found is, therefore, no reason why those found should not belong to the genus *Ctenodus*.

"Since the publication of the above remarks in 'Scientific Opinion,' Messrs. Hancock and Atthey have published a paper in the 'Annals and Magazine of Natural History,' and in the 'Transactions' of the Tyneside Naturalists' Field Club, in which they attempt to prove that the lenticular bodies which I described

as otolites are not otolites, but vegetable fungi, to which they have given the generic name *Archagaricon*, a name which indicates that they resemble hardened fossil mushrooms. Their chief arguments in favour of the vegetable nature of the fossils are the minute structure of some of the specimens, which resemble, to some extent, the structure of certain fungi; and the fact that while fossil bones are easily destroyed in nitric acid, the supposed otolites are not perceptibly affected by the action of the acid. In reference to the fungoid characters of those bodies, Mr. W. Carruthers, of the British Museum, in his review of the contributions to fossil botany published in Britain in 1869 ('Geological Magazine,' 1870, p. 182), says: 'The authors describe a number of lenticular bodies from the Cramlington Black Shale, which, from their resemblance to *Sclerotium stipitatum* (Berk. & Curr.), they consider to be fungi. These fossil bodies are supposed by Messrs. Hancock and Atthey to be fully developed plants, producing spores, and related to the higher fungi. The authors have overlooked the fact that this "doubtful" (Berk.) production, which led them to take this view of these bodies is only a *Mycelium*-tuber, the fructification of which is yet unknown.'

"In minute structure these fossils vary, and, as some of them appear to be entirely structureless, structure alone is not sufficient to justify their being considered vegetable. With respect to the effect of nitric acid on the fossil, my experience has shown that nitric acid does not visibly affect the forms of the supposed otolites: while it decomposes teeth and other remains of fishes and reptiles, it nevertheless produces so much of chemical change upon them as to render the previously transparent dilute nitric acid somewhat milky in appearance, indicating the presence of calcareous matter in the otolite. Taking all the facts of the case into consideration, it appears more probable that the fossils are otolites of fishes, rather than hardened fungi."

Mr. Barkas's description of this fossil are, to my knowledge, perfectly accurate, and if I had only attended to their structure I should have considered the bodies as vegetable; but, besides the fact of one specimen being found accompanied by undoubted remains of *Ctenodus*, there are also two other points in favour of the otolite conjecture, and which have not been noticed by either of the above palæontologists, viz.: (1) that the shale in which these bodies are embedded does not contain any vegetable remains, at least, I have never seen any; (2) that it is difficult to conceive of any mushroom-like fungus becoming fossilized in coal-shale to such a degree of hardness, for they are more dense than the strongest fossil tooth or bone. No doubt there is something to be said on both sides, we must, therefore, for the present consider the nature of these bodies as obscure; they may be otolites of *Ctenodus* or other fish, or they may be fungi.

Part VI.

On the Scapula (?), Coracoid, Ribs, and Scales of Ctenodus.

By W. J. Barkas, M.R.C.S.E., L.R.C.P.L.

The next bone I have to notice is as yet doubtful as to its nature, its discovery being rare; when discovered it has been occasionally found associated with remains of *Ctenodus*, but whether it is really a portion of the skeleton of that fish is not determined. Its shape is also such as to render its diagnosis uncertain; it does not resemble any bone in *Ceratodus*, but bears a certain degree of likeness to the carpal bones of *Gyracanthus*. This much can be said about it, that it is a bone belonging to the scapular or the pelvic girdle of some fish, and the reasons that I speak of it now are that it has been found associated with *Ctenodi* remains, and also that the markings on its surface differ little, if at all, from the ornamentation of undoubted bones of *Ctenodus*. With this provision, therefore, I shall enter into its description, and I may state that it has not to my knowledge been either described or figured. The bone is triangular in shape, the apex being much thicker and stronger than the base; the basal extremity is a thin plate with an irregular border; the upper and lower borders that proceed forwards to form the apex are thick and strong, the upper being gently curved downwards to the apex, the lower presents an abrupt concavity close to the point which gives a hooked appearance to that part; the apex is rounded, and fits into the articular cavity of the bone that I shall next mention, an undoubted coracoid of *Ctenodus;* the portion between the two borders rapidly thins as it proceeds from the apex towards the base. The whole surface is pitted and striated with a horizontal tendency, but nowhere does it present the reticulation found in other fossil fish or reptile bones. Such being the conformation of the bone, I infer that it pertains to the scapular arch and is the scapula itself. Should this bone be hereafter proved to be a scapula of *Ctenodus* or any other fish, it will present one great point of difference from the majority of scapulæ, in that its articular extremity is convex and fits into a cavity in the coracoid, instead of *vice versa*. The coracoid of *Ctenodus* has been obtained both by Mr. T. P. Barkas and Mr. Atthey, but its discovery is comparatively rare. When discovered it is generally associated with other remains of *Ctenodus* that are undoubted; in fact Mr. Atthey reports that he has obtained a

portion of the body of *Ctenodus obliquus* in which the pair of bones are *in situ*. The coracoid was referred to by Messrs. Hancock and Atthey in their paper on *Ctenodus* and *Dipterus*, but it was not figured. I am not aware that Mr. Barkas has published any account of it, though he has specimens in his cabinet. As Mr. Atthey's description resembles the specimen in my possession I shall quote it. "Their general character is that of a flattened elongated bone, with one end a little expanded, arched slightly, and gradually thinned out to a fine edge; it narrows a little towards the other end: one of the lateral margins is slightly thickened and is somewhat convex; the opposite margin is a little concave. From the narrow extremity a strong wide process is given off at right angles, and extends considerably beyond the concave margin. These bones vary a good deal in size and form: some are comparatively narrow and much elongated, others are short and broad, but all have the right-angular process at the narrow extremity. The largest are four inches and three-eighths, and the smallest five-eighths of an inch in length." The account is incomplete, as it does not refer to the glenoid cavity at the narrowed extremity that is formed by the prolongation of the lower border, and the abrupt termination of the upper margin in what is termed the pectoral condyle. Into this cavity, as I have already remarked, the rounded apex of the supposed scapula in my possession fits. A comparison of this fossil bone with the coracoid or clavicle of *Ceratodus* after its cartilages have been removed shows a close resemblance; there is, however, not any sign of a suture in the coracoid of *Ctenodus*.

The vertebral column of *Ctenodus*, as I have mentioned in Part V of these papers, was probably cartilaginous, as no remains of them have been disinterred.

Jugular plates, we may infer, for the same reason, were absent.

The ribs of this fish are osseous, and are found in comparative abundance both disassociated and associated with teeth, head-bones, &c.; Messrs. Atthey and Barkas having great numbers in their cabinets. They have been figured by Mr. T. P. Barkas in this "Atlas." Mr. Atthey thus describes them: "They are well arched towards the proximal extremity, which is considerably enlarged; and the central channel is quite small, the cylindrical wall of bone being very thick: the ossification of the ribs is, in fact almost complete. The largest ribs are from six to eight inches long." A rib in my possession shows another very remarkable character of these ribs, the presence of an united fracture. Ribs that have been fractured during life and have thrown out "callus" which has become ossified enough to be fossilized, are frequently discovered; as many as three fractures have been observed in a single rib. A microscopical examination displays all

the structure usually found in the "callus" of a reunited bone; a full account of this structure was given by Dr. Embleton in a paper read before the Northumberland and Durham Medical Society.

The exo-skeleton may still be considered in a state of doubt, as the chief authorities, Mr. Barkas and Mr. Atthey, differ. Mr. Atthey asserts that he has discovered the scales of *C. elegans* and *C. obliquus*, and gives descriptions and figures of three, one belonging to the former and two to the latter species; while Mr. Barkas doubts their being scales of *Ctenodus*, and this he does in the following words, quoted from his "Coal Measure Palæontology":—"Although nearly 1,000 teeth of *Ctenodus* have been found in the Northumberland Coal Formation, and a large proportion of those teeth of considerable size, and although many teeth of the *Ctenodi* have been discovered in Staffordshire and elsewhere, it is a remarkable fact that, up to the present time not a single specimen of a large scale has been found at all resembling the reputed scales of *C. elegans*, and there are not any uninterpreted or undescribed scales discovered in the Northumberland or Staffordshire Coal Measures that can with propriety be assigned to *Ctenodus*. As scales are vastly more numerous than teeth, if 1,000 teeth of scaled fishes have been discovered, and each fish had only four or six teeth, it is surely improbable that all the scales belonging to those fishes would have eluded discovery." This argument is a common one in Palæontology; Mr. Atthey applied it to prove that it was not probable that *Ctenodus* had incisor teeth, but we have seen that his own future discoveries disproved his deduction. The reputed scales of *C. elegans* are thus described by Messrs. Hancock and Atthey, in their paper on "*Dipterus* and *Ctenodus*." In *Ctenodus* the scales are elongated and parallelogrammic, with the posterior end well rounded, and the sides nearly parallel or a little hollowed or concave: they are in length nearly twice their width, and, though imbricated, can scarcely be called truly cycloidal: they are delicate and large for the size of the fish, and are longitudinally ridged or grooved; the ridges, becoming curved and nodose, form a sort of rosette in the centre of the exposed imbricated portion." These scales were obtained from what they considered to be a complete fish of that species, but they add that it was "much crushed and disturbed"; certainly the engraving they publish of the fossil does not give much promise of founding any discoveries upon it. The scales of *C. obliquus* appear to have better evidence in their favour, for the above conjoint authors state, in a foot-note to a paper entitled "Descriptive Notes on Fish Remains found in the Coal Measures at Newsham," that they had obtained "a fine specimen of the greater portion of the cranium and part of the trunk of a large *Ctenodus*

with the opercular plates attached; a considerable number of the ribs are exhibited in connexion with the head, disposed in natural order. Everywhere mixed up with this interesting specimen these peculiar scales are found, much broken, indeed, but occupying both sides of the body portion of the fish, in such a manner as to leave no doubt on the subject. The scales are very similar to those described in the text, differing only specificially, the margin being wider; the smooth central area has the same peculiar minute surface structure, and the upper surface is minutely granulated in the same manner." In the paper itself he portrays the scales: "they are parallelogrammic in form, are thin and delicate, and apparently represent three species, though the distinguishing characters are slight.

"The first, the largest and most perfect specimen, measures two inches and a half long, and upwards of two inches wide. The sides are parallel, the anterior extremity is a little arched outwards, and the posterior or exposed extremity is rounded; the angles are rounded off; the central area, under an ordinary hand-lens, appears quite smooth, and is bordered by a rather narrow margin having several concentric undulations or lines of growth, and marked with minute radiating striæ; no growth lines are visible within the marginal border. On examination with the inch object-glass, the central area is found to be finely reticulated with slightly elevated bony fibres, the meshes being sunk, so that the surface is minutely punctate. This is undoubtedly the under-side of the scale; the upper surface is revealed on fragments, and, at a rupture near the centre of the rounded exposed extremity, is minutely granular. Of course, in the latter case, it is only the cast of the upper surface that is seen; and at this point it is evident that the granules are enlarged and become arranged so as to form imperfect and very irregular vermicular grooves.

"The second species is less perfect than that just described; the greater portion, however, of the scale is preserved; but the border of one side is gone, as well as the posterior margin, and part of the anterior. The sides are slightly convex, and so is the anterior extremity, the angles being rounded; the border is wide, and distinguished by several concentric lines of growth, and five minute radiating striæ, as in the first species. The central area is likewise similar; but the minute surface-structure is finer, and the bony network has the meshes drawn out in the long axis of the scale; the punctures are not so large and distinct. This fragment (for fragment it is) measures two inches long, and one inch and one-eighth wide.

"The third species, which has lost the greater portion of the rounded posterior extremity, and is in other respects imperfect, is upwards of an inch and three-fourths long; it seems to have

been more nearly square than either of the other two forms, and is characterized by a very narrow border, which shows only one or two concentric lines of growth and minute radiating striæ. The bony network of the central area is fine and indistinct, with a longitudinal arrangement of the meshes, as in the second species; the punctures are numerous, rather large, and longitudinally oval.

"The last description is apparently of a mere cast of the under surface; but a small portion of the scale, exhibiting the upper surface, is adherent, and proves that it is minutely striated in an irregular broken manner, the striæ for the most part having a longitudinal disposition.

"The peculiar rectangular form distinguishes these from all the cycloid scales with which we are acquainted; and they are much thinner than any other of the *large* scales of the Coal Measure fishes. The only scale that can be compared to them in this respect is that usually attributed to *Rhizodus*—the scale which we described some time ago as belonging to *Archichthys*. But this scale is pretty regularly rounded, is more coarsely granulated on the surface, and usually exhibits concentric lines of growth over the whole surface; it is also generally found split open, exposing to view the internal structure, when the concentric lines of growth and minute radiating striæ are sharply defined over the entire surface. The scale of *Ctenodus* is never seen with the internal structure thus exposed: at least we have never seen the concentric lines of growth and radiating striæ pass beyond the border, the under surface being usually exposed to view. This is well shown in our second species, the specimen being preserved on one slab in relief, the cast of the under-side in intaglio on the other."

Concerning these scales I myself can say nothing. I have examined hundreds of teeth, ribs, head-bones, opercula, &c., of this fish, but I have never seen a scale in association with them; and I know that no other palæontologist than Mr. Atthey had ever discovered any, previous to my departure from England, though many have diligently searched in the same pit. I do not doubt Mr. Atthey's statements at all, but it is strange, as remarked by Mr. Barkas, that *Ctenodus* scales should be so rare while all its other parts are comparatively common. Granting, then, that Mr. Atthey's discoveries are correctly diagnosed, for I have never had the opportunity given me of even seeing these specimens, there can be no hesitation in affirming their close similarity in form to the scales of *Ceratodus*. Reasoning from analogy would certainly lead one to infer that *Ctenodus* had scales.

The forms of the fins and tail are also unknown to me, but Mr. Atthey, from the one crushed specimen of *C. elegans* he possesses, and to which I referred in speaking of the scales,

thinks that "the fins, as far as they can be made out in *C. elegans*, are arranged as in *Dipterus*. The tail fin is heterocercal and rhomboidal, and the anal and ventral can be traced immediately before the caudal." As this specimen is the only one upon which any trace of a fin or tail has been detected, and as it is acknowledged to be much injured, it will be advisable to leave this portion of the fish's structure to be determined by the investigations of future inquirers.

I have now entered in great detail into all the fossil remains of this fish that have been discovered, and we have seen that only in two points are there any marked differences between *Ctenodus* and *Ceratodus*, viz., in the arrangement and shape of the bones entering into the formation of the upper portion of the cranium and the ossification of the ribs. If we include those bones that are supposed to pertain to *Ctenodus*, but that are not yet distinctly proven to do so, we must add two other differences, the peculiarity of the scapula and the presence of otolites. With the exception of these four points, *Ctenodus* is identical with *Ceratodus* in its fundamental construction, so far as it is known, even in those parts that yet may be considered somewhat doubtful, such as the scales. When we take into consideration the distant period in which *Ctenodus* lived we can hardly expect that the type could have been handed down to the present time, countless ages intervening, without a few alterations of structure due to the differences of circumstances. During the Coal period the river mouths and brackish estuaries in which *Ctenodus* lived were the abode of huge Selachians armed with terrific teeth, and often with enormous dorsal and pectoral spines, much larger and more powerful than those of the present day; against these *Ctenodus* would have to defend itself when in the waters; for this purpose the solid thick shield of the cranium and the ossified ribs were probably sufficient. Then when this fish made its way out of the waters on to the dry lands or upon the swampy coasts, its life would be in danger from the huge Batrachians that swarmed; it would then require strength in the fore-arm to force its body back into the waters, resulting in the development of the scapula and coracoid for greater muscular attachment. Finally, the much greater size of *Ctenodus* would necessarily require a larger and firmer surface for the attachment of the powerful muscles that propelled the huge body through the waters, for, judging from the size of the teeth, ribs, opercula, &c., it has been estimated that some of the species were much over six feet in length. With none of these dangers has the modern fish had to contend; therefore, in the great battle of the "survival of the fittest" less strength has been required of it, and consequently in the process of time an alteration would take place in the skeleton, to render it compatible with existing circumstances.

With regard to the food of *Ctenodus* nothing can be ascertained, as fossil dung (coprolites) has never been found associated with its remains, but from the shape and arrangement of the teeth we can easily infer that it fed upon crustaceous and testaceous animals, and probably upon some of the smaller fishes like *Palæoniscus*. Some amount of certainty is given to this guess by the fact that the coprolites of fishes that swam in the same waters as *Ctenodus* have been obtained, and in them we find remains of the above forms of animal life.

On the Tertiary Deposits of Australia.

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The subject of Australian tertiary geology has not, as far as I can learn, occupied much of the attention of the Royal Society of New South Wales. Owing to the very extensive development of the palæozoic, metamorphic, and volcanic rocks on the eastern cordillera of our continent, the tertiary formations have escaped attention; yet they are certainly an important element in our geological history, and deserve a speedy elucidation at the hands of naturalists in New South Wales. The marine cainozoic rocks of Australia cover at least a fourth part of its surface. The interest they possess, not only for ourselves but for Europe, can scarcely be overstated. As far as they have been studied they have revealed facts which are of almost startling importance to the science generally, and lately some of the discoveries will materially modify long received conclusions. This will appear as I proceed with the following paper, which I intend as a brief *résumé* of the present state of Australian tertiary geology. Such an epitome has long been wanted, not only by men of science, but by the public generally. The time is not far distant, let us hope, when a popular exposition of Australian geology can be prepared. The materials are sufficient, or nearly sufficient. While awaiting this, what I here bring before the notice of the Society may serve as a contribution to the subject, and I am encouraged to the task by the fact that most of what I shall state is new to the public.

Before I refer to what has been done, I beg to draw attention to the special interest the subject has for the natural history of New South Wales. There can be no question that tertiary formations are extensively developed in this Colony. They are no doubt chiefly volcanic or alluvial, with drifts and travertine of various ages; but their nature and position have not been studied—the marine formations have hitherto absorbed all the attention of geologists in Australia. This has not been owing alone to the special attractions they must ever have and the facilities for their study, but also because no satisfactory attempt at the correlation of strata can ever be made until something like a basis has been established by fossils of the relative position

of marine strata. But as on the east and south sides of Tasmania, so in New South Wales, tertiary marine strata are not known. This is a significant fact, which has a far more important influence on our geological history than is supposed. But while marine strata are not visible, volcanic strata, freshwater deposits and drifts, all clearly tertiary, are abundant. No attempt, or at least no successful attempt, has been made to classify them. It is possible that nothing short of an actual and careful survey would reveal the age and relative position of these rocks, yet something might be done even by amateurs. That all our volcanic rocks possess features of their own, by which they may be recognized almost as surely as if they contained fossils, is a probability which investigation is daily raising to a certainty. In Victoria the miscroscopical and analytical researches of Mr. Ulrich have revealed astonishing facts. Already the augitic and hornblendic rocks are found to arrange themselves chronologically, and, as far as the learned and industrious mineralogist has gone, show an important bearing on the question of auriferous rocks. It may be said to be almost established that no volcanic emanations belonging to different periods, *e.g.*, the miocene and pliocene, will be found to have the same mineralogical characters. This then of itself would simplify the question of our tertiary volcanic geology, and when once taken in hand will not leave us long to wait for valuable conclusions. In the meantime I draw attention to the subject as a most interesting and untrodden field for observation, and I trust that my remarks on tertiary Australian geology may induce observers to stray into a field where an easy and abundant harvest awaits them.

Tertiary marine strata cover the whole or very nearly the whole southern portions of the Australian continent, from about the 125th to the 145th meridian of east longitude. There are interruptions to these beds, more or less; on the east side the formations get more and more narrowly confined to the sea, until they disappear altogether. On the Australian Bight they are uninterrupted, and extend very far from the coast line. They are all very rich in fossils, very well preserved in some cases, and in others masses of casts and broken shells. The peculiar character of these shells will be dealt with presently.

The interruptions to the continuity of the tertiary beds are of much interest. Throughout their course on the level country they are continually broken into by islands of red granite rocks, which are nearly the only elevations in the vast sandy plains of the deserts. Besides these small interruptions there are mountains, notably two large ones. The first, on the eastern side, is the South Australian chain, beginning at Cape Jervis at the mouth of St. Vincent's Gulf, and terminating in what was formerly erroneously regarded as the horseshoe bend of Lake

Torrens. A little further on the eastern side of this range the tertiary beds succeed in unbroken plains to the valley of the Murray. A little to the east of the boundary between South Australia and Victoria the country becomes singularly overlaid by basalts of middle tertiary or later tertiary origin, while a remarkable dome-like area of tableland forms an extensive interruption of some two or three thousand square miles in extent. This is apparently lower mesozoic, cut through by the Wannon and Glenelg Rivers. To the east it is again interrupted by the supposed lias or trias ranges of the Grampians and Victoria ranges. The tertiary rock still maintains its prevalence near the coast, and probably no more complete series of the deposits can be found anywhere than between Warrnambool and Cape Otway. This latter feature is the projecting portion of a range which forms a remarkable interruption, but at Geelong and on the western side of Port Phillip the tertiary formation again appears. The spur of the Dividing Range which abuts upon the sea at Wilson's Promontory is probably the final barrier to the tertiary beds, though some of them may yet be traced close to the sea in Gippsland.

Other and minor interruptions there undoubtedly are, but generally it may be said that a great semi-circular basin of tertiary rocks occupies the southern portion of the Australian continent, much in the way originally represented on the very clear sketch map of the geology of Australia by the late Mr. Jukes. A more detailed map has been recently given to the public by the Victorian Government, on which the same general features are given, but the detailed information attempted is not so reliable. Many of the places marked there as silurian in South Australia are really occupied by tertiary rocks, notably the eastern side of the shores of St. Vincent's Gulf, north of Willunga.

Various attempts have been made at some kind of classification of these beds, but no satisfactory system has yet been adopted, and it may be doubted whether the materials are as yet extensive enough for the purpose. Professor Duncan is of opinion that the whole of the deposits should be included under the general title of cainozoic, until the existing fauna shall be well enough known to admit the percentage system to be applied. This also will require a far better knowledge of the fossils than we have at present. The fauna of different beds in widely separated localities show that the results obtained so far are somewhat perplexing. Yet there are certain characters which seem to prevail. In order to understand these, I must give an account of what has been done towards the classification of Australian marine tertiary fossils. Strezelecki was the first in the field, but this only resulted in the determination of a single species. The next attempt was that of Professor Busk in 1859 (*Proceedings Geological*

Society). This was confined to Polyzoa. My humble efforts followed in 1862 (*Geological Observations in South Australia*), but this resulted in little more than a few figures and names. Professor Duncan immediately afterwards took the corals in hand, and in a series of papers in the *Geological Society's Proceedings*, threw great light on the nature and affinities of our fossil corals, from materials supplied by myself. In 1865 I published figures and descriptions of several of the more remarkable *Brachiopoda* occurring in the Mount Gambier formation, with a few *Echinodermata* and some conchifera (*Pectinidæ*). These were published and the figures lithographed by me in the Proceedings of the Adelaide Philosophical Society. In 1869 *Dr. G. C. Laube, in the Sitz. d. k. Akad. d. Wissen. Wien* (*Vienna*) *B. lix. Ab.* 1, 1869, *p.* 193, figured and published a very extensive catalogue of the *Echinodermata*, naming a number of new species from the Murray River beds. Shortly afterwards Professor M'Coy commenced the publication of his decades of Australian Palæontology, which left nothing to be desired in the figures or descriptions of the species named. But as the decades include other besides tertiary fossils, the descriptions, so far, do not describe many species; all, however, of the highest interest. In 1874, during a missionary visit to Tasmania, the Council of the Royal Society there placed at my disposal for classification a number of fossils in the Society's Museum, collected by Dr. Milligan, Mr. Stephens, and Mr. R. M. Johnston. The collection showed me at once that the great tertiary formation of Australia extended to the north-west portions of Tasmania. Among well recognized forms I saw many new and interesting species all new to science, and I therefore described them, the figures being executed by that accomplished natural-history artist, Mrs. Charles Meredith. Subsequent investigations by Mr. Johnston enabled him to write several most interesting papers on the deposit, all of which appeared in the Proceedings of the Royal Society of Tasmania; and at the same time he placed so valuable and so complete a series of fossils at my disposal that I was enabled to make a very full comparison of the Tasmanian beds with those of Australia. In all, I succeeded in settling the characters of from seventy to eighty fossils new to science, only very few of which have been hitherto found in Tasmania alone.

In the meantime the Geological Survey of Victoria has been very active, and a series of reports and papers have appeared with important papers on the fossils, from Professor M'Coy and Baron von Müller. Mr. Etheridge, jun., of the English Geological Survey, has also taken an active interest in the matter, and two valuable papers have appeared. In the first (*Geological Society's Proceedings*) he has described a new *Hemipatagus*—*H. Woodsii* (*Lovenia*, var.?), and then given a complete *résumé* of

all that has been published on the subject of the Australian fossil Tertiary Echinodermata. In the second (*Annals of Natural History*) he has described some new *Brachiopoda*. But a most valuable accession to our Australian geologists has been in the arrival of Professor R. Tate, of the Adelaide University. He has entered upon his labours with a zeal and industry which bids fair soon to place him far in advance of all other observers in Southern Australia. Already his syllabus of the lectures given shows that he has made important discoveries, and in his private correspondence with myself has made known facts of the highest interest, to which I may refer just now. I may mention, also, that in my correspondence with T. Davidson, the most eminent of British, nay of European palæontologists, in his particular department (the Brachiopoda), I have forwarded all the fossils I could meet with belonging to this most interesting order. I take this opportunity of stating that from no scientific man have I ever met such kindness and courtesy. Trouble seems nothing to him, and his brilliant talents and vast knowledge are cheerfully at the service of the youngest amateurs. His observations on the Brachiopoda are full of interest, and I would place them in full before the Society, but that I know Professor Tate is preparing a monograph for publication on the same subject, which will shortly be accessible to all.

I will now proceed to notice how far the investigation of the fossils has thrown light upon Australian geology, and what relation our tertiary beds bear to similar formations in Europe. And first as regards the term tertiary. We do not pretend by that term to recognise many of the fossils here as identical with what are known as tertiary fossils in Europe. The formations which make up that group are thus classified because they contain either a certain percentage of species still existing, or because by their general contents they make a gradual approach in their typical organisms to the fauna and flora of the present day. Now in Europe the knowledge of the existing fauna, though hardly complete as far as marine life is concerned, is sufficiently so to enable naturalists to say with tolerable accuracy what percentage of fossils in any given bed belong to species which still exist. But in Australia our knowledge of marine life is almost confined to what is called the littoral zone. And to make this partial knowledge still more disadvantageous, I have not met many, or indeed I may say any truly littoral species, in all the tertiary beds I have examined. Neither have we any formation preserved to us, as far as I have been able to ascertain, which can be called the remains of a coast or littoral deposit. This circumstance renders us unable to apply the percentage test, and thus deprives us of those opportunities of classification, or rather correlation, with European deposits which would justify

the employment of such terms as oligocene, miocene, &c. This Professor Duncan has pointed out, and has suggested the employment of the word cainozoic as a general term to distinguish those lower tertiary beds which contain the commencement of our modern fauna or new life. While quite agreeing with the learned professor in this, my long acquaintance with all the tertiary formations and my familiarity with the fossils induce me to offer a few suggestions which I think may carry our knowledge a little further. If we cannot apply the percentage system, we can, at least, form general conclusions from superposition, distribution, &c., as to the chronology of the series—if I may so speak. And it seems to me that we must not entirely disregard what I may term a family likeness in the deposits. We must remember that at the present day the existing fauna of widely separated seas, which have scarcely any species in common, have a general resemblance, in the prevalence of certain genera in certain habitats. Thus I suppose there are no seas where some forms of *Littorina*, *Patella*, *Trochus*, *Buccinum*, *Cardium*, *Pectunculus*, and *Mytilus* do not inhabit the rocks and sands. And some of the species bear so close a general resemblance that it is only after a careful comparison we can see specific differences. Now, we ought to see a similar general resemblance in the faunas of very widely separated areas which belong to the same epoch; and this, in fact, we do see, and, as far as my observation goes, almost justifies us in correlating our deposits with similar formations in Europe. I believe, however, that it is a generally received opinion that, as we go further back in time, so we find a wider range for species, until in the earliest deposits we find little specific variety all over the world. It is not quite so certain, however, that where widespread specific identity begins to fail, that close affinity still shows the influence of the former rule. It seems to me, however, that it is so, and it has an important bearing on facts which I now adduce. At present in Australian seas we have a series of molluscan provinces, all united by one general Australian *facies*, yet all with distinct characters peculiar to each. To any one conversant with Australian conchology it would be easy to tell at a glance to what province any given collection of shells belonged. For my own convenience I have been accustomed to divide the Australian seas into five molluscan provinces outside the tropics. These are,—1, Sydney, or Eastern; Victorian, or South-eastern; 3, Adelaide chain; 4, the Tasmanian; 5, South-western; the latter ranging from Port Eucla to Cape Leuwin. Now each of these provinces has species of its own and species in common. Observation as yet will not permit us so far to say with certainty how many of the species now identified are no more than local varieties. However, we can be certain that for those species

which have a wide distribution, we see a great difference between specimens gathered in different provinces. Take for instance *Mytilus latus*, Lamk., or the common Australian mussel, which is one of the few shells common to Australia and New Zealand. In the latter place it is a large and often partly yellow shell. In Tasmania it is a brilliant olive green, changing with age into a dull purple. In New South Wales it is a tumid shell of dull olive, and in Victoria it is of the Tasmanian colour and shape, though with peculiarities of its own. This is by no means so favourable an instance as the less known *Patella tramoserica*, which has received a good many names from naturalists in its time. But from those or other instances that might be alleged, we find pretty certainly manifest at the present day local differences of form, character, &c., in otherwise identical species. Now it seems to me that there is not the same variety in our tertiary beds, and that this greater or less variability in remote districts might be made to form a valuable guide to the chronology of the deposits. One thing, however, is certain, which is that the species common in our tertiary beds have a much wider range than any species have now. To prevent the fact being applied too far, let us bear in mind that the deposits are not littoral, but rather that of the laminarian zone. 2nd. That colour, which is an important element in estimating variety in existing shells, is absent from the fossils. 3rd. The tertiary area at our disposal for investigation, though wide, is not nearly so extensive as the area of the provinces enumerated by me. Still, making all those deductions, my observations incline me to the conclusion that we have in our tertiary formations a much greater uniformity in marine life, and species more constant in character, than what is witnessed in the present Australian seas. This fact may seem of small importance in estimating our chronology, but I venture to submit that it is a clue which will lead in the end to valuable data. Whether we could ever hope by its aid to erect sub-divisions in our tertiary formations may appear doubtful, yet it must be of importance until the percentage system can be applied.

The oldest portions of our tertiary beds, as far as we can judge from the contained fossils, appear to be about Schnapper Point, Mount Martha, and Western Port. Here the blue clays, and the general appearance of the contained fossils, forcibly remind one of the eocene beds of West Barton, in Hampshire; and as Professor M'Coy has long ago pointed out, there is a good deal more than mere external resemblance. Some of the fossils closely imitate in character the fossils known in the English beds by what the learned professor has termed "mimetism." The resemblance is so close that some might even suppose the identity of the fossils. This is especially seen in *Voluta antiscalaris*, M'Coy, and

V. anticingulata. But these fossils, it must be added, are also found in newer formations, such as Table Cape in Tasmania, and Muddy Creek in Western Victoria. The general character of the Mount Martha and Schnapper Point beds is first in the beautiful state of preservation in which the fossils occur. The most delicate markings and fine edges are as fresh as if they were just dredged up from the deep. The clay in which they are found is of a light blue or ash grey colour. *Foraminifera* are not common, at least not so common in this finely levigated mud as in many of the higher beds. *Polyzoa* are also the exception. Pedicillate corals are, however, numerous, few of existing species, but of characters similar to those now living in the Japanese and China seas. There are none peculiar to this formation, at least as far as the beds have been explored, and that, it must be admitted, is only slightly. An undescribed *Nisso*, and a beautifully marked *Pleurotoma*, also caught my attention, as well as a *Fusus*, so like the beautiful and delicately spined *F. pagodus* of the Philippines, that it has, I believe, been named *Fusus pagodoides* by Professor M'Coy.

Above those beds, and not separated from them by any very clear line of demarcation, we find a series of different deposits of some thickness and very wide spread. The characteristics differ in different localities. In the Geelong beds, and then westward from Cape Otway to Warrnambool, we meet with clays and muds, sometimes intercalated with plant remains, and a long succession of horizontal or slightly inclined stata. The precise number of the beds exposed has not been clearly ascertained, but they represent a very long series of deposits and an extensive period in our tertiary geology. To the north of Warrnambool they are found at a place called Hamilton, or around it, in the form of light brown clays, very rich in fossils. They are overlaid in places by a thick hard rock of ferruginous or ochreous limestone, entirely composed of polyzoa and the fragments of shells. The whole district is overlaid by much later outpourings of volcanic matter, so that the tertiary rocks become hidden, but there is little doubt that they are underneath, as, when wells or shafts are sunk to any depth, if they pierce through the basalt, the polyzoan limestone is reached. Now and then we find outcrops of granite, but even there traces of the tertiary formation appear. At a creek near Harrow, in Western Victoria, about 600 feet above the sea, we find, on the slopes of the granitic formation, a thin clay of a few inches thick, full of highly ferruginous fossils. These are hard and glazed, and have evidently owed their preservation to their ferruginous character, since the beds wherein they were deposited have entirely disappeared, and the fossils lie entangled in the grass, which is almost rooted in the granite. They are all of species common in the

Geelong beds, such as *Cucullæa corioensis*, *Pecten yahlensis*, (Tenison-Woods); *Cassidaria reticulospira* (M'Coy); *Placotrochus deltoideus* (Duncan).

Not very long ago it would have been difficult to name many of the fossils found in this immense series of deposits, but since the labours of M'Coy, Laube, Duncan, Etheridge, already referred to, and my own humble efforts, so large a number of the organic remains have been arranged and classified that it would be quite beyond the limits of this paper to give even a list of names. I propose, however, with the permission of the Society, to publish subsequently in the Proceedings a list of the names, authorities, and exact references where they may be found, as an easy aid to palæontological researches, which is very much required.

In Tasmania we find the same deposits, but under different conditions. The matrix is rather a muddy gravel than clay, and contains fragments of what are evidently the remains of a basaltic rock. There are also an immense number of rounded quartz grains, and the whole formation suggests the proximity of some granitic and basaltic rocky shore. The fossils are not different from those of Victoria, but only different from the character of the fauna in the same locality now. In describing over, I think, ninety fossils from those beds, I did not meet half-a-dozen similar to those now existing on the coast, and those only of shells which are now of rare occurrence. *Fissurella concatenata* (Crosse) is a case in point, and one or two which are doubtfully referred to European forms still existing, or of miocene age. Corals abound throughout the formation, whether in Victoria or Tasmania. One form, *Placotrochus deltoideus*, seems to prevail everywhere, and is very common; but no characteristic eocene form, such as *Turbinoli*. *Balanophyllia* is a genus which is richly represented, but the species in Tasmania are different, and one closely allied form, *Dendrophyllia*, has two species departing very widely from any known forms. In Victoria no reef-building coral was found, but in Tasmania I discovered a *Heliastræa* (*H. tasmaniensis*, Dunc.) to be not uncommon, together with a *Thamnastræa* (*T. sera*, Dunc.) not hitherto found in Australia. The general conclusion forced upon palæontologists by the fossils is that the seas were then much warmer than they are now. The types approach nearer to the fauna of the Philippine Islands and China Seas than anything now living near Australia. It is true that two or perhaps three species of *Trigonia* are found, but these are rather abnormal forms. The strictly Australian ones, such as *Elenchus*, *Cominella*, *Bankivia*, *Trochocochlea*, *Phasianella*, *Thalotia*, *Siphonaria*, &c., are not represented even generically, except a doubtful *Thalotia*.

It is a remarkable circumstance of the fauna of these beds that there has been discovered at Table Cape, Tasmania, one almost perfect skeleton of a wallaby, *Halmaturus* (?), imbedded in a soft

yellow sandy clay full of marine fossils. They are principally small *Turritellæ*, *T. Warburtoni*, *mihi*, and others. There is nothing whatever to lead one to suppose that the animal was not deposited at the same time as the shells. It may have been carried out to sea by a flood from some coast stream, or it may have been dropped into the sea by a bird of prey. There it lies, however, firmly imbedded among the fossils, a land animal among marine shells. I was not able to ascertain whether the remains could be referred to any existing species. The specimen lies in the Museum of the Royal Society at Hobart Town, where unfortunately there are no marsupial skeletons for comparison. It seemed to me to be the remains of an animal stouter in proportion to its length than any we are acquainted with now. The fossil is of great interest, because first of all it points out the great antiquity of the marsupial fauna of Australia; and secondly, will serve as a guide to the interpretation of some of our cave remains.

At Portland, nearly on the western limit of Victoria, we have a commencement of a newer tertiary formation, known as the Mount Gambier or Polyzoan limestone. It is quite different in character from the lower strata we have been considering, and has been fully described in two publications of mine—viz., "*Geological Observations in South Australia*," and "*Two Lectures on the Geology of Portland*"—both of which are now in the Society's library. It has also been continually noticed in the reports of the various geological surveyors to the Mining Department of Victoria. I shall not therefore describe it now, but refer to some features which have not been previously noticed. First of all the deposit is distinguished by the abundance of *Polyzoa* and *Foraminifera*, of which, indeed, it is principally (nay almost entirely) composed. The greater part is a kind of marble, very loose and friable, which seems to be composed of broken foraminiferæ. The other fossils may be easily enumerated. They are few and far between, and may be said to comprise *Echinodermata*, *Brachiopoda*, and *Pecten*, and even these are scarce, except one urchin. This is *Lovenia Forbesii* (Woods and Duncan).* This lies on strata a few inches thick, with no other fossil, showing how curiously they must have flourished in the days of their existence. Now that we have the deep-sea dredging as a guide in estimating the conditions of life at great depths on the ocean floor, we easily understand what we see here. Sometimes the dredge of the "Challenger" would come up full of one kind of echinidæ, as if there was nothing else to be found. Here we see a similar thing in former times. There are also a few

* This fossil urchin was first named by me as *Spatangus*, but subsequently described by Professor Duncan as *Hemipatagus*. The same Professor has recently shown (in Q. Jour. Geo. Soc., 1877, p. 56), by a careful examination of many specimens, that the fossil is a *Lovenia*.

little belts of *Terebratula compta* (Sow.) The deposit is evidently one prevailing at great depths, and very different from its fauna from what we see at the same depths now. In Portland there is a good opportunity for observing the sequence of the tertiary beds and the volcanic outpourings. Tertiary marine strata and recent basaltic rocks are regularly intercalated. Some of these volcanic rocks have evidently been poured out under the sea, and there are two recent craters still visible in the midst of the waves, namely, what are called the Lawrence Rocks and Lady Julia Percy Island. The latter is about seven miles from the shore, and is a crescent-shaped island of almost tabular elevation entirely composed of volcanic ejectamenta. I propose, however, to give a paper on the tertiary volcanic phenomena of Australia, and therefore will not pursue this subject further.

The tertiary beds are found almost universally, unless where interrupted by the volcanic rocks, granite hills, or islands, as we may call them, until the Great South Australian chain or Adelaide Range is reached. They are, however, very much concealed near the coast by very recent pliocene and pleistocene deposits. The beds exposed on the banks of the Murray have never been submitted to a detailed examination by an experienced palæontologist until Professor Tate has taken them in hand. Some of his conclusions have been communicated privately to me; but I refrain from saying more on the subject, as the public will soon hear of them from himself. The same remark must apply to the tertiary beds on the western slopes of the Adelaide chain, about the mouth of the Onkaparinga River. These beds have been long known to me as containing quite a different series of organisms. They seem to me as older than even the Western Port beds; but my opportunities for examination were very limited. Professor Tate informs me that he has found characteristic upper mesozoic fossils among them, though he regards the beds as tertiary.

I find that at a meeting of the Geological Society of London, February 7, 1877, a paper was read from Professor Tate, on new species of *Belemnites* and *Salenia*, from the middle tertiaries of South Australia. The fossils were named by him *B. senescens* and *S. tertiaria*. They were obtained at Aldinga, where, he said, the fossils were for the most part identical with those of the Murray River beds. The *Salenia* was hitherto supposed to be extinct, and a characteristic mesozoic form, but a living species had been dredged up by the "Challenger." In the discussion which ensued, the President, Professor P. Martin Duncan, remarked upon the interest attached to the discovery of this Belemnite, which added another to the curious examples of the survival of older forms of life in Australia. He thought it could hardly have been derived from secondary strata. The *Salenia* was evidently tertiary, and, as it was somewhat cretaceous in its aspect,

added another to the cretaceous forms which had outlived the cretaceous period. This and similar discoveries showed the impossibility of comparing Australian and English strata on purely palæontological data. Mr. J. S. Gardiner remarked, in connection with the discovery of cretaceous forms still living in modern times, that American cretaceous beds may be like our eocene. If a Belemnite lived on into the tertiary period, this might give quite another reading to those supposed cretaceous beds, whose determination rests mainly upon their flora. Mr. A. W. Waters said that two years ago he exhibited to the Society Belemnites from Ronca. Since then it has been shown that in the deposit at Ronca there are boulders from older beds, so that although his Belemnites are not rolled, and he regarded them as probably tertiary, the evidence must be considered incomplete. These *Belemnites* were like liassic forms, but very unlike those discovered by Mr. Tate. The Rev. J. F. Blake said that Professor Tate's specimens were more like oolitic than cretaceous forms, and they certainly did not belong to the genus *Belemnitella*. The carrying on of cretaceous forms into tertiary times favours the idea of a non-uniform deposition of beds, and a more continuous succession of life in Australia than in Europe. Professor Rupert Jones said that in 1857 *Belemnites* found in a tertiary deposit north-west of Germany were exhibited at the meeting of the Naturalists' Association at Bonn. Professor Seeley remarked that it was impossible from the material before the Society to determine the species to which the *Belemnite* belonged. The characters were not sufficiently clear to show whether it was a true *Belemnite*, or might form a distinct but allied genus. He agreed with Mr. Gardiner with regard to the resemblance of American cretaceous shells to those of the English tertiaries. Professor Duncan reminded Mr. Blake that there is a sharply defined cretaceous formation in Australia.

If I should venture to suggest anything in this matter, it would be that our tertiary formations are older than the period hitherto assigned to them. I do not think either that our cretaceous formation, which is near the equator and remote from these beds, is quite so clearly defined as imagined; neither is it safe to say that the southern analogues would be so very different from our lower tertiary beds, though I am far from saying that they would be the same. They may, however, be nearer to each other than is at present believed.

Westward of the Onkaparinga and Aldinga beds we have the tertiary formation well represented in some parts of Yorke's Peninsula. At Kadina, Moonta, and the Wallaroo mines generally, fossils are found at a small depth below the surface, mostly Echinoderms (*Arachnoides australis*, *Lovenia Forbesii*). These are well known forms of the Murray River beds, and perhaps they occupy

the same geological horizon. They completely, or almost completely, cover the cupriferous veins, which are in true hornblendic or dioritic dykes. The deposit seems widely spread on Yorke's Peninsula.

Westward of these deposits we have the thick fossiliferous formation of the great Australian Bight, which extends for 300 leagues in an unbroken wall, abutting on the ocean at heights ranging from 300 to 600 feet, and all one mass of fossils. I believe this to be a geological phenomenon almost unequalled in extent and peculiarity on the surface of the earth. All the fossils I have seen from these beds have been familiar forms from Victorian or South Australian beds. I should imagine, from the description of the beds themselves, and the fossils submitted to me, that they were nearer to the Mount Gambier formation than those of the river Murray. I have however, never seen a good series of fossils from the cliffs of the Australian Bight, and no doubt they would be of the highest interest, and modify many of our conclusions made. I cannot help thinking that there has been no slow upheaval in the case of the Australian Bight. The cliffs, sometimes 600 feet high, abut upon the ocean without any sign of that wearing process which surely slow and gradual upheaval would cause. There is very strong, nay conclusive evidence, that the close of the miocene period, or rather the dawn of the existing fauna, was ushered in by extensive volcanic disturbance; and this, no doubt, caused very great changes of level and upheaval, some of which was clearly sudden and extensive. It is difficult to interpret the facts in any other way. It seems to me pretty clearly established that the whole central parts of the coast of Southern Australia were almost suddenly upheaved from the sea.

I now append a few notes on the *Brachiopoda* of the tertiary in Tasmania which has formed the subject of my inquiries for some time past. I accompany it with an outline sketch to assist in understanding some of the species to which I refer. I have submitted all the specimens to Mr. Thomas Davidson, Professor M'Coy, and Professor Tate, and I append after each species their remarks.

A *Rhynchonella cœlata*, M'Coy MS.: Rounded trigonal, with a strong mesial fold, with many fine imbricated ribs. "From several miocene beds in Victoria."—M'Coy. "A most beautiful species, very closely related to *R. nigricans*, from New Zealand. Some examples in external shape cannot be distinguished, but I have not observed on any recent *R. nigricans* such prominent and strongly marked imbricated striæ. The fold and sinus seems more strongly marked on the fossil form. The ribs also seem smaller and more delicate than on real *nigricans*."—T. Davidson. "Aldinga, one specimen."—Professor Tate.

No. 1. *Waldheimia imbricata, nobis*, *W. macropora*, M'Coy, MS. "Called so from pores which separate it from *W. flavescens*, to which I drew attention many years ago when printing that name. I do not, however, know how it can be separated from Davidson's *W. Garibaldiana*."—Professor M'Coy. "This species has much the character of *W. flavescens* or *Australis*. I have not a good collection of Australian recent species of *Brachiopoda*, but have one that has a good deal of general similarity to this fossil from Table Cape, Tasmania, but none that has exactly the same shape. It would be well to compare with *W. flavescens*. It is a new but allied species, and has also a little resemblance to my *W. Garibaldiana*, although I think not the same species. The sub-pentahedral elongated shape is remarkable, but it is difficult to guess at the variations a species may assume by the inspection of a single specimen."—T. Davidson. "The commonest Brachiopod in the middle beds of the Murray cliffs."—Prof. Tate.

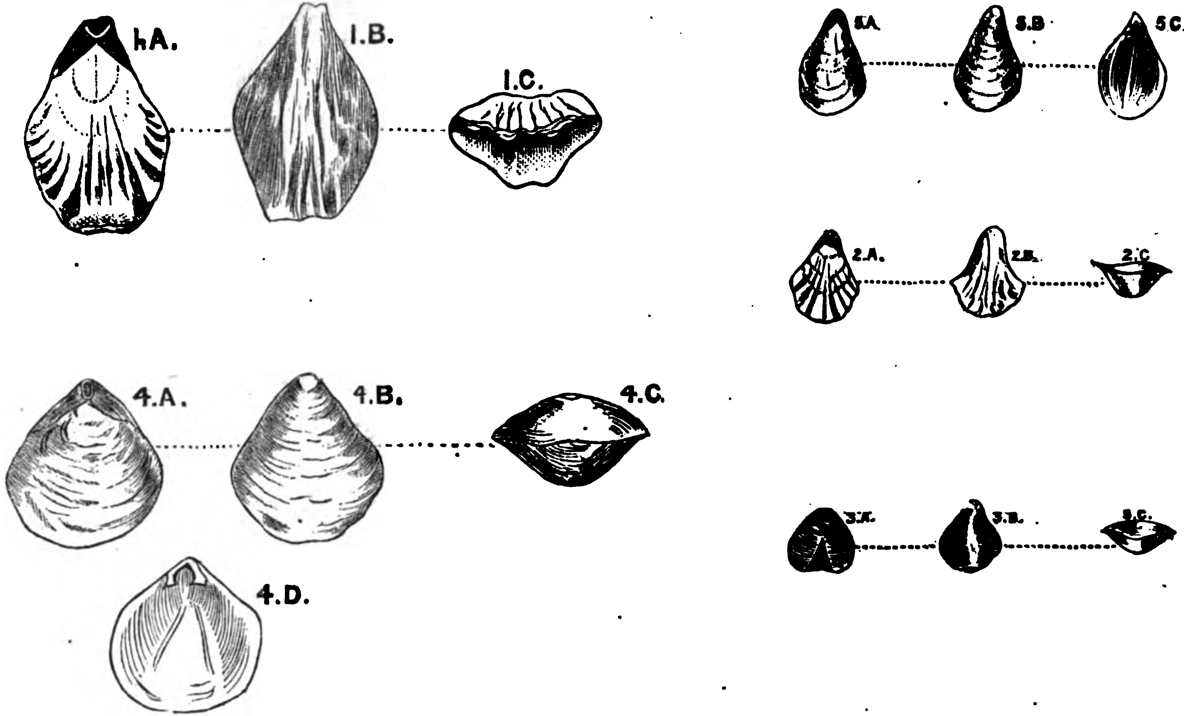
No. 2. Young of preceding, T. Davidson. Professor M'Coy did not recognize it with certainty. Professor Tate thinks it may be a *Terebratulina* common to Aldinga and Table Cape.

No. 3. *Waldheimia corioensis*, M'Coy, MS.: "I do not know this species with a broad depression on the smaller valve. It seems to me to be quite new."—Davidson.

Terebratula gambierensis. Ether. Ann. Nat. Hist. 1875. "A biplicated species approaching to the Italian tertiary *T. pedemontanæ*, but still distinct, being more regularly oval. It is, however, very difficult to distinguish the numerous closely allied biplicated *Terebratulæ* from the Jurassic, Cretaceous, and Tertiary periods. It is singular that, although biplicated species of *Terebratulæ* are so abundant in the Jurassic, Cretaceous, and Tertiary periods, that hitherto not a single species so constructed has been found alive or in the recent conditions."—T. Davidson. "Common at Aldinga. Another variable species, sometimes without biplications."—Professor Tate.

No. 4. *Terebratula vitreoides*, n. s. A small, smooth, orbicular species, with very conspicuous concentric lines of growth. Foramen small. I only figure and name this fossil provisionally, of which Mr. Davidson says, "This is another of those undecided forms that resemble many things described as distinct species. It has some resemblance to *T. vitrea* or to *T. orbiculata*, Sequenza. I would not like to assign it positively to any of the species, although I would not assign to it any very distinguishable features. I think you should publish a description and figures of these very interesting species, not only on account of the species, but of the formation and locality from whence they come."

No. 5. *Terebratula Tateana*, n. s. Small, smooth, without ribs or folds, closely allied to *T. compta* (Sow.) Beak somewhat produced. The specimens sent to Mr. Davidson too small or imperfect for determination.



EXPLANATION OF PLATE.

No. 1. *Waldheimia imbricata:* *a* dorsal valve, *b* ventral valve, *c* front view of margin.
No. 2. Young, sp.? *a* dorsal valve, *b* ventral valve, *c* front view of margin.
No. 3. *Waldheimia coriensis*, M'Coy: *a* dorsal valve, *b* ventral valve, *c* front of margin.
No. 4. *Terebratula vitreoides*, n. s.: *a* dorsal valve, *b* ventral valve, *c* front view of margin, *d* loop.
No. 5. *Terebratula Tateana*, n. s.: *a* dorsal valve, *b* ventral valve, *c* loop.

Discussion.

The Chairman said the paper was particularly interesting to him, and the discussion of the subject brought many things to his remembrance. He was born on the tertiary formation of East Anglia, and had lived for years in the tertiary district of Dorsetshire, as well as on those of the continent. He had also written on the subject of tertiary formations. He would take the liberty of making one or two remarks on the valuable paper just read. First, relating to the genus belemnites as tertiary. In the county of Suffolk, belemnites occur in great abundance *over* the tertiaries. But they so occur with gryphytes as drift in the boulder clay. It now appears, however, that not only is belemnites found to have tertiary species in Australia as well as elsewhere, and that there are a great number of instances in which fossils belonging to one particular epoch have survived to a more recent period. It is the case in parts of India; and in Australia plants assumed to be younger are found in beds of our carboniferous formation. It is in such cases proved that there is a passage from one formation to another without those immense breaks which geologists once thought necessary. He had one other remark to make respecting the coasts of Australia. The great banks of tertiary deposits along the Australian Bight overlie granite. In his "Notes on the Geology of Western Australia" (see Geological Magazine, vol. iii, p. 503 and p. 551), will be found a statement made to him by the late Captain Stanley, R.N., respecting a depth of water off the Bight amounting to nearly four miles, which in his "Notes" he shows to be possible. This might be so, even if elevation has since taken place. Between Cape Howe and Cape York no marine tertiaries have yet been found, though tertiary fossils have been brought from New Guinea. Along the east coast there appears to have been a sinking of the land in places which can be explained, in accordance with the Barrier Reef theory of Darwin, Probably this has been the case in earlier than tertiary times. with the district between Sydney and the elevated area of the Blue Mountains at the back of Penrith, and elsewhere on the coast, and thus notwithstanding elevations, there have been subsidences.

The Rev. W. Scott moved a vote of thanks to Rev. Mr. Woods. This was the first time they had had a paper read by an honorary member.

The motion was carried unanimously, and the Chairman conveyed the thanks of the Society to Mr. Woods.

Rev. Mr. Woods, in reply, expressed the pleasure he felt in having any part in the investigations of this Society. In reference to Mr. Clarke's statement as to the belemnites,—possibly they were derived fossils. It was said that no such interpenetra-

tion was admissible. If they were derived, we should expect to find them under different conditions. What he had seen convinced him that it was a mass of fossils accumulated in the sea. It was said there were, in the Bight, fossils found in North Australia. He had noticed one or two tropical forms there. As for the strata, he would hardly be prepared to say they were the same as the Murray cliffs, but the fossils were clearly tertiary. As to the subsidence of the eastern side of the continent, Mr. Clarke was more competent than any other man living to form an opinion. As to the depth found by Captain Stanley, he (Mr. Woods) thought four miles hardly a reliable one in those early days. As far as he had heard, there seemed to be a gradual shelving; but there was evidence of great subsidence, or of upheaval.

On some New Australian Polyzoa.

By Rev. J. E. Tenison Woods, F.G.S., &c., Hon. Mem. Roy. Soc., N.S.W.

[*Read before the Royal Society of N.S.W., 4 July, 1877.*]

The following two new species of Serialaria belong to the family *Vesiculariadæ* (order Infundibulata, sub-order 3, Ctenostomata). It is now some years since I noticed the first, but had no opportunity to examine it until the year 1874, when by the aid of that experienced microscopist and scientific statist, Mr. W. H. Archer, F.L.S., &c., I was able to determine its character. I may say here that Mr. Archer made all the necessary investigations with the aid of his very extensive microscope apparatus, and the drawings were made by Mr. J. R. Y. Goldstein of Warnambool, under the direction of Mr. Archer.

Serialaria—*Lamarck*. Character:—Polypidom confervoid, horny, fistular, and branched. Cells, tubular, uniserial, and unilateral, disposed in close parallel companies in internodes at stated intervals.—Johnston, "Brit. Zoophytes," vol. i, p. 368.

Serialaria Australis. sp. nov.

S. polyzoarium with the internodes completely occupied by seven to ten tubular cells, adnate to one another, perpendicular to the frond, curved, and lengthening towards the end of the series. Internodes serial, or giving off two others at right angles. Two long ligulate processes proceeding apparently from the terminal cell mouths of each internode. These are about twice the length of the internode. Mouth of cell somewhat crescentic, with a thickened margin.

Found after storms in masses amongst seaweed in Guichen Bay, South Australia. It is of light brown colour, and very like a mass of aphides. The transparent fistular branches, whence the cells arise, are corrugated and constricted at the internodes. In section they appear rhomboidal. Some of the cells seem to be provided with a conical cap. Are these ovicells?

This species is very close to *S. lendigera*, Lamarck, but it is much more stout and solid, the cells are in a *double series* and quite fill up each internode, while there are frequently long vacant spaces in the British species. The ligulate processes are double at the end of each internode, while they are often single and only occasional in *S. lendigera*. See *Johnston, Brit. Zooph.*, 1st edit. (1838), p. 251, fig. 40. In Ellis's *Nat. Hist. of the*

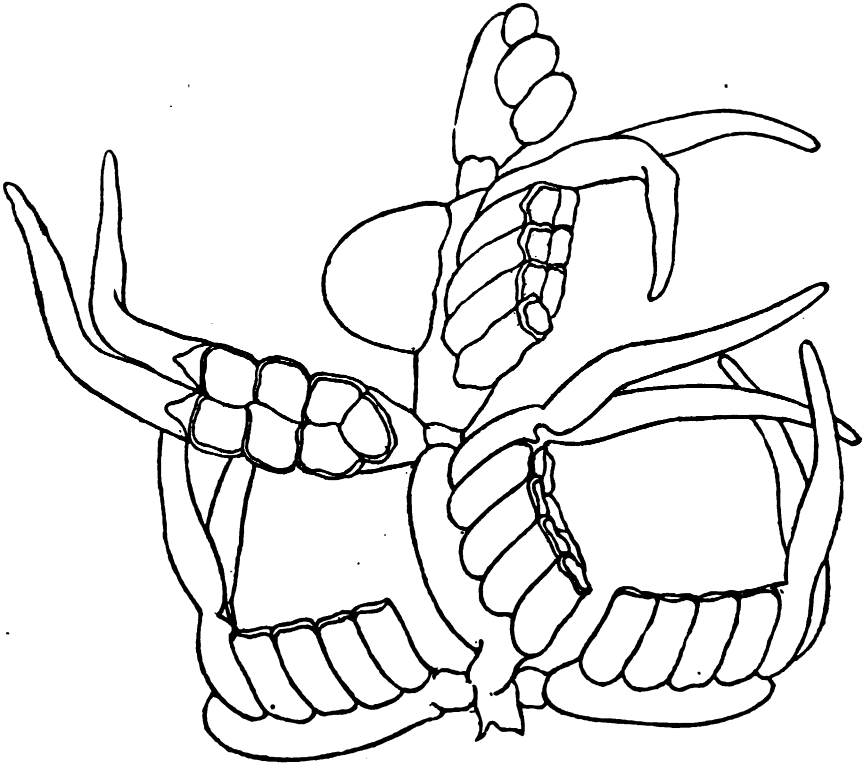
Corallines, Lond., 1755, at p. 27, we find the following notice of that species:—"*Corallina exigua, caule geniculato, scandens, vesiculis ex unoquoque geniculo sic dispositis, ut syringam Panis referent. Fucoides Lendigerum capillamentis cuscutæ instar implexis.* Nit Coralline. This extremely small climbing coralline arises from very minute tubes by which it adheres to fucuses and other marine bodies, and is so disposed from its jointed shape that it climbs up and runs over other corallines and fucuses as dodder does over other plants. The vesicles have the appearance of rows of denticles are placed in such a regular order on the end of each joint that when they are magnified they represent the antique figure of Pan's pipe. I have called it the Nit Coralline from Mr. Ray's calling it the Nit-bearing Fucoides. The small vesicles closely-jointed together in little speck-like figures among the irregular capillary branches gives us some idea of that form." I may add that the Australian species does not, as far as I am aware, climb over sea-weed as above described.

SERIALARIA SPIRALIS. sp. nov.

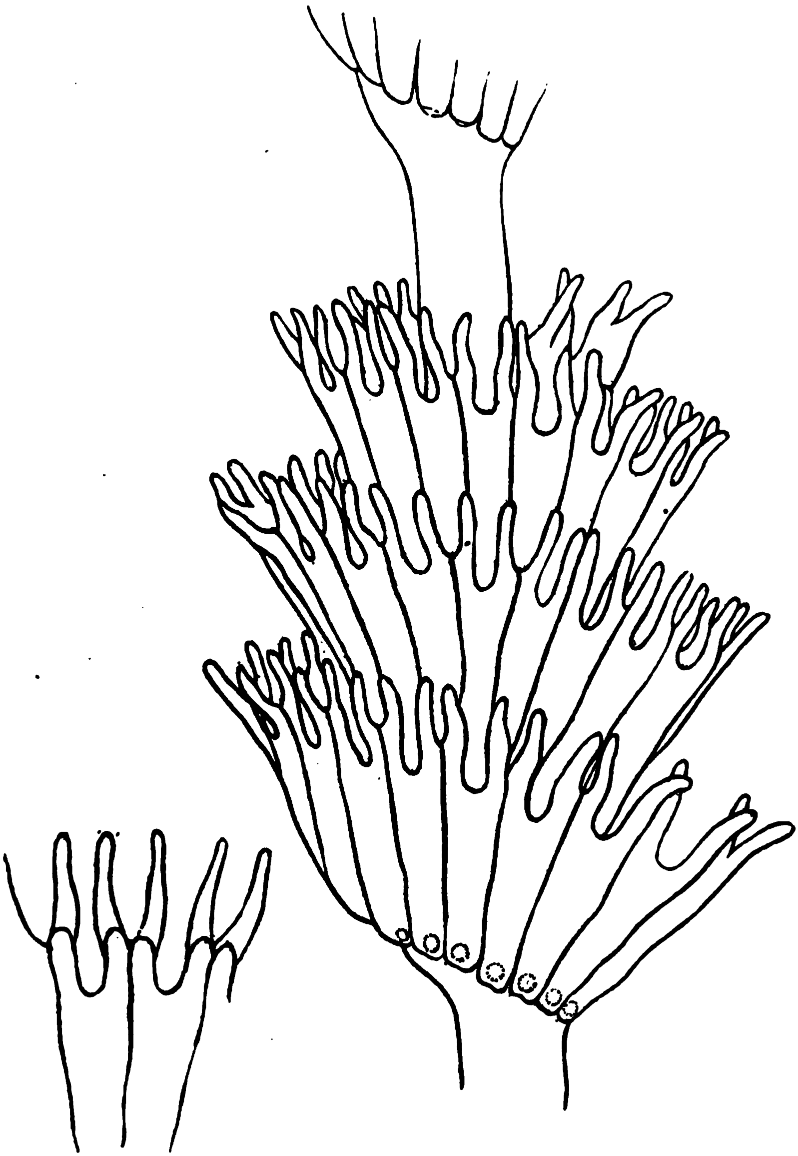
S. p. dichotomously branched with clusters of cells in series of twenty to twenty-four, disposed spirally round the axis of the branches. Cells flat, nearly four times as long as wide, each provided at the mouth with two divergent hollow spines half as long as the cell.

Common at various places on the southern coast of Australia and in Tasmania. The spiral disposition of the cells distinguishes this species from all others. In appearance it is like little masses of fine knotted fibre or a delicate moss. Under the microscope it seems at first like a series of little conical cups placed one within another, and surrounded with spines. It is not easy to trace the gradually ascending spiral series of cells, as their transparency blends their different parts into a confused mass. The cells on the summits of the branches are usually incomplete, and have their spines truncate and hollow. The clusters of the internodes form an easy receptacle for grains of sand, shell, and *foraminifera*, which also tends to confuse the aspect of the structure. Ovicells in large oval cups at the base of some of the spirals. Colour, dark brown.

It is to be remarked that neither of the above species polarises, whereas the calcareous polyzoa all show well defined peculiarities of structure under the polariscope. It would be an interesting inquiry to determine the nature of the substance which we call *horny* in these organisms.



SERIALARIA AUSTRALIS. *Tenison-Woods.*
(Highly magnified.)



Serialaria spiralis. *Tenison-Woods.*
(Highly magnified.)

On the occurrence of Chalk in the New Britain Group.

By ARCHIBALD LIVERSIDGE, Professor of Geology and Mineralogy in the University of Sydney.

[*Read before the Royal Society of N.S.W., 4 July*, 1877.]

IN the following brief notice it is my wish to communicate to the Society a description of the physical properties and chemical composition of one of the geological specimens recently brought from the above group of Islands.

The specimen which I now have the pleasure to lay before you is not only interesting in itself as an example of what is known as an organically formed rock, since it is built up almost entirely of the calcareous skeletal remains of organic forms, but it is interesting in a still higher degree, as it apparently indicates that a most important geological discovery has been made of the presence of chalk in an hitherto unknown and even unsuspected locality.

In October last the Rev. G. Brown, Wesleyan missionary, brought (amongst other specimens) from New Britain and New Ireland (New Britain Group, latitude 4 degrees south, and 150 degrees east longitude) certain grotesque figures of men and animals, which had been carved by the natives of the above islands out of a soft white somewhat pulverulent material, having much the appearance of plaster of Paris or chalk.

Some of these figures were deposited in the Museum, and a fragment broken off from one of them was placed in my hands for identification.

On examination, the remains of numerous foraminifera are at once detected, the forms of the larger ones being plainly visible even to the unaided eye; under the microscope the whole mass of the rock is seen to be almost entirely composed of the shells and fragments of shells of foraminifera, the remains of globigerina being most abundant.

To obtain the shells of the foraminifera free from the cementing calcareous matter, it is only necessary to gently rub the surface of the specimen with a soft tooth or nail brush under a stream of water, when the whole surface of the fragment submitted to the operation speedily becomes studded with the minute shells and fragments of shells of foraminifera, now left standing out in relief.

To obtain the foraminifera perfectly free from the accompanying powder, it is sufficient to dry the collected *debris* and to place it

upon the surface of some clean water contained in a glass beaker or other vessel; the larger and more cavernous foraminifera float on the surface of the water, while the broken fragments, much of the amorphous powder, and many of the denser foraminifera, are deposited at the bottom of the vessel as a sediment. The very light and finely divided parts are got rid of by decanting the milky supernatant liquid.

In the sediment the microscope reveals the presence of the smaller foraminifera, of a few sponge spicules, and minute grains of what are evidently siliceous and igneous rocks.

The further examination showed that the material is limestone, having a very close resemblance to chalk, both in chemical composition and in physical properties; in colour it is not the dazzling white of some chalk, but bears a closer resemblance to the light grey varieties.

Although it is essentially composed of carbonate of lime, still it is not perfectly pure; there are certain impurities present, in the form of alumina, iron, silica, manganese, and other substances; but reference will again be made to this question later on.

To ascertain whether my supposition that the rock might be regarded as chalk and not merely as a soft white friable recent limestone, or as a deposit such as is now forming over parts of the beds of the Atlantic and Pacific Oceans, I took an early opportunity, when writing, to enclose a portion of the material to Mr. H. B. Brady, F.R.S., of Newcastle-on-Tyne, who has devoted himself to the study of foraminiferous deposits, and who is recognized as one of the first authorities upon these matters. I have since received a reply from him, in which he says:—

"First, let me speak of your chalk from the New Britain group. I suppose you have ascertained that it is a cretaceous chalk, and not a friable tertiary limestone. All the foraminifera, or nearly so, are south Atlantic recent deep-sea species, *Globigerina bulloides*, *Gl. inflata*, *Pulvinulina Menardii* (a thick variety which I do not think is yet named), *P. Michelimiana*, and probably *P. Karsteni*, *Pullenia spheroides*, *Nonionia depressula*, *Bulimina Buchiana*, fragments of *Dentalina*, *Uvigerina*, &c.; also a characteristic *pulvinulina* with thick shell and honeycombed surface, not yet described, of which I have quantities in the "Challenger" material * * * The whole of the "Challenger" foraminifera have been handed over to me to work out."

In answer to a question as to the locality and mode of occurrence of the material used for the carvings, The Rev. G. Brown wrote to me as follows:—

"The chalk of which the figures are formed is, I am informed, only found on the beach after an earthquake, being cast up there in large pieces by the tidal wave; it is only found, as far as we know at present, in one district on the east side of New Ireland."

We have now to consider its chemical composition in somewhat closer detail, and to compare the results furnished by it on analysis with those yielded by specimens of typical or true chalk.

Chemical Composition of Specimen from New Ireland.

Hygroscopic moisture, *i.e.*, water driven off it, 100° C	1·202
Carbonic anhydride	35·337
Iron sesquioxide	1·597
Alumina	3·131
Silica	7·933
Phosphoric acid	Minute trace
Manganese protoxide	·623
Lime	45·278
Magnesia	·476
Potash	·308
Soda	·260
Chlorine	·105
Combined water and loss	3·750
	100·000

Specific gravity, 2·199 at 59° F.

The specific gravity was taken from a mass weighing about 78 grammes, which was allowed to soak in water for about one hour and a half, in fact until all air bubbles ceased to be evolved; a small quantity of the block scaled off when immersed in the water—a correction for which had to be made.

The above figures show that in round numbers about 81 per cent. of the specimen consists of calcium carbonate; thus it is undoubtedly a far less pure limestone than the ordinary white chalk, as the following figures indicate:—

Chemical Composition of Chalk from other Places.

A specimen of chalk, from near Gravesend, which was analyzed by Mr. W. J. Ward, yielded the following results:—

Calcium carbonate	98·52
Magnesium carbonate	·29
Calcium sulphate	·14
Manganese binoxide	·04
Phosphoric acid	traces
Organic matter	—
Insoluble matter, chiefly silica	·65
	99·64

Mr. David Forbes, F.R.S., also examined some specimens of chalk, the analyses of which are here cited. The first analysis shows the composition of a piece of white chalk from Shoreham, in Sussex; and the second of a piece of grey chalk from Folkestone.

	White Chalk.	Grey Chalk.
Calcium carbonate	98·40	94·09
Magnesium carbonate	·08	·31
Phosphoric acid, Alumina and loss	·42	trace
Sodium chloride	—	1·29
Water	—	·70
Insoluble rock debris	1·10	3·61
	100·00	100·00

(*Vide* "Geology of England and Wales." Woodward, p. 239.)

Another sample of chalk obtained from a well at Driffield was found by Mr. T. Hodgson to have the following composition:—

Moisture	5·20
Calcium carbonate	93·30
Magnesium carbonate...	·15
Iron sesquioxide and alumina ...	·20
Silica	1·15
	100·00

The specimen from New Ireland closely resembles in chemical composition the chalk-like rock occurring in New Zealand.

Dr. Hector, C.M.G., F.R.S., Director of the Geological Survey of New Zealand, publishes in his Annual Report for 1875-6, the description and analysis of a limestone made by Mr. Skey, chemist to the Survey, as follows:—"No. 1,767. Chalk, contributed by Mr. H. Higginson, from South Canterbury, very closely resembles some taken from the same district by the Survey some time since. These samples, as to their physical and chemical character, also their general appearance, exactly represent the chalk of the cretaceous formation as occurring in England."

Analysis.

Carbonate of lime	84·12
Carbonate of magnesia	2·10
Clay	12·57
Iron oxides and alumina, soluble in acid	1·21
	100·00

It is, however, far less impure than the "chalk mud" of the Atlantic, for the analysis quoted by Professor Sir Charles Wyville Thomson, F.R.S., in his "Depths of the Sea," p. 469, show that the "chalk mud" contains merely some 60 per cent. of calcium carbonate, and with as much as from 20 to 30 per cent. of silica, and varying proportions of alumina, magnesia, iron, and other substances.

The same author mentions that the typical chalk is free from silica, and so it would appear to be from the above quoted analyses; but the "insoluble rock debris" of the late talented David Forbes, F.R.S., probably consisted largely of silica.

The only locality for chalk in the Pacific Islands to which I can find any reference occurs in Professor Dana's work on "Corals and Coral Islands." See p. 308. But this even is not true chalk; it is merely a recent limestone derived from disintegrated corals, and which resembles chalk.

Mr. Dana there says—

"The formation of chalk from coral is known to be exemplified at only one spot among the reefs of the Pacific.

"The coral mud often looks as if it might be a fit material for its production. Moreover, when simply dried, it has much the appearance of chalk, a fact pointed out by Lieutenant Nelson in his memoir on the Bermudas (1834), and also by Mr. Darwin, and suggested to the author by the mud in the lagoon of Honden Island. Still this does not explain the origin of chalk, for, under all ordinary circumstances, this mud solidifies into compact limestone instead of chalk, a result which would be naturally expected. What condition then is necessary to vary the result and set aside the ordinary process?

"The only locality of chalk among the reefs of the Pacific, referred to above, was not found on any of the coral islands, but in the elevated reef of Oahu, near Honolulu, of which reef it forms a constituent part. It is 20 or 30 feet in extent, and 8 or 10 feet deep.

"The rock could not be distinguished from much of the chalk of England; it is equally fine and even in its texture, as earthy in its fracture, and so soft as to be used on the blackboard in the native schools.

"Some imbedded shells look precisely like chalk fossils. It contained, according to Professor Silliman, 92·80 per cent. of carbonate of lime, 2·38 of carbonate of magnesia, besides some alumina, oxide of iron, silica, &c.

"The locality is situated on the shores, quite above high-tide level, near the foot of Diamond Hill. This hill is an extinct tufa cone, nearly 700 feet in height, rising from the water's edge, and in its origin it must have been partly submarine. It is one of the lateral cones of Eastern Oahu, and was thrown up at the

time of an eruption through a fissure, the lava of which appears at the base. There was some coral on the shores when the eruption took place, as is evident from imbedded fragments in the tufa; but the reef containing the chalk appeared to have been subsequent in formation, and afforded no certain proof of any connection between the fires of the mountain and the formation of the chalk.

"The fine earthy texture of the material is evidence that the deposit was not a subaerial sea-shore accumulation, since only sandstones and conglomerates, with rare instances of more compact rocks, are thus formed. Sand-rock making is the peculiar prerogative, the world over, of shores exposed to waves, or strong currents, either of marine or of fresh water. We should infer, therefore, that the accumulation was produced either in a confined area, into which the fine material from a beach may have been washed, or on the shore of a shallow, quiet sea—in other words, under the same conditions nearly as are required to produce the calcareous mud of the coral island. But although the agency of fire in the result cannot be proved, it is by no means improbable, from the position of the bed of chalk, that there may have been a hot spring at the spot occupied by it.

"That there was some peculiar circumstances distinguishing this from other parts of the reef is evident.

"This, if a true conclusion, is to be taken, however, only as one method by which chalk may be made; for there is no reason to suppose that the chalk of the chalk formation has been subjected to heat; on the contrary, it is now well ascertained that it is of cold water origin, even to its flints, and that it is made up largely of minute foraminifera, the shells of rhizopods.

"Professor Bailey found under his microscope no traces of foraminifera, or of anything distinctly organic, in the chalk."

The entire absence of any remains of foraminifera must, I venture to think, completely destroy any claim for the Oahu limestone to be regarded as chalk proper.

Neither can the Atlantic ooze, rich though it be in coccoliths and the shells of foraminifera, be regarded as chalk. It is true that it may in future geological ages fulfil Professor Wyville Thomson's prediction and become such, but even of that we cannot be certain. At present it is a soft calcareous mud, and a very impure one. When consolidated and converted into dry land, instead of forming a brilliant white chalk limestone, a hard compact argillaceous or siliceous slaty limestone may be the result.

The true white chalk so familiar to Englishmen is found over an area extending from the southern part of Sweden to Bordeaux, a distance in round numbers of 850 miles, and again from the northern part of Ireland to the Crimea, *i.e.*, about 1,140 miles.

I am, of course, referring to the extent merely of the soft white limestone known emphatically as chalk, not to the areas

occupied by that great variety of rocks which are classed with the chalk, and which are collectively known as the rocks of the chalk or cretaceous period, from the fact that they contain certain fossils in common.

Rocks belonging to the chalk or cretaceous period have a very wide distribution, being found in Europe, Asia, Africa, America, and in Australia from Western Australia to Queensland, and New Zealand.

It may, perhaps, be mentioned as an argument in favour of the probability of the New Ireland limestone being properly regarded of cretaceous age, that we have cretaceous rocks in Queensland as far north as 11° S., and in New Guinea, still nearer to New Ireland, we have rocks which undoubtedly belong to the mesozoic or secondary period, for amongst the geological specimens brought by Signor D'Albertis from the Fly River, and submitted to me for examination, there were *belemnites*, an *ammonite* (this ammonite bears a very close resemblance to a liassic form) and other fossils, such as *carcharadon teeth* and *pectens*, all of which may or may not belong to the cretaceous age.

It would be by no means a startling thing to find that these secondary beds had an extension to the New Britain group of Islands, a distance of only a few hundred miles, which would comprise an area by no means equal to the extent of country occupied in Europe by the typical white chalk.

It should, however, be mentioned that no true white chalk has yet been found either in Queensland or in New Guinea.

In conclusion, it may be stated that the principal reasons in favour of the rock being regarded as chalk are that physically it is almost indistinguishable from most typical specimens of that rock, and that it has had the same organic origin; the foraminifera alone are not, unfortunately, sufficient to rigidly determine the geological age of the specimen, because they are types which have been persistent from the cretaceous period to the present time.

On a Method of Extracting Gold, Silver, and other Metals from Pyrites.

By W. A. Dixon, F.C.S., Cor. Mem. Nat. Hist. Soc. Glasgow.

[*Read before the Royal Society of N.S.W.*, 1 *August*, 1877.]

Some three years since, Mr. Wood, Under Secretary for Mines, suggested to me that the extraction of gold from complex minerals was a subject well worthy of investigation, and one which if brought to a successful issue would be of great value to New South Wales and Queensland. Both these Colonies yield minerals containing gold, and that often in considerable quantity, but so mixed up with sulphides of copper, lead, iron, and other metals, that none of the ordinary methods of treatment extract more than a very small proportion of it.

Acting on this suggestion, I obtained some pyrites from Mariner's Reef, Gympie, which in the rough yielded on analysis :—

Copper	6·2 per cent.
Lead...	·19 „
Gold...	3 oz. 3 dwts. 2 grs. per ton.
Silver	32 oz. 9 dwts. 3 grs. per ton.

Another larger portion from the same reef, after being ground and washed so as to remove as much as possible of the quartz, which was found to amount to about 60 per cent. of the rough mineral, gave—

Copper	17·02	or	Copper pyrites	48·45
Lead	2·01		Iron „	35·95
Antimony	3·9		Galena	2·31
Gold and silver ..	·22		Sulphide of antimony ...	5·44
Iron	31·41		Sulphide of arsenic ...	·68
Sulphur	37·86		Gold and silver	·22
Silica	7·16		Silica	7·16
Arsenic and loss	·42			
	100·00			100·21

Gold ...	12 oz. 10 dwts. 0 grs.	per ton.
Silver ...	62 oz. 9 dwts. 16 grs.	

I had also a small lot of copper pyrites from this Colony containing 24 per cent. of copper, and gold equal to 78 oz. 8 dwt., and silver 4 oz. 2 dwt. 10 grs. per ton; arsenical pyrites containing when thoroughly roasted 11 ozs. 18 dwts. 0 grs. per ton; iron pyrites containing when roasted 5 ozs. 6 dwts. 3 grs. gold per ton.

As much attention has been given, by others more conversant than myself with mechanical manipulation, to the extraction of gold and silver, by grinding with mercury in variously designed apparatus, with comparatively small success so far as these complex ores are concerned, I have confined my attention principally to those chemical relations of gold which would enable me to obtain it in solution. I may note, however, that in Germany ores containing more than 1 per cent. of copper, or 7 per cent. of lead, have not been found suitable for amalgamation; and that an increase of density of the accompanying gangue from the presence of heavy spar, &c., or of tenacity from the presence of clay, seriously reduce the yield of precious metals, consisting in their case principally of silver; and that nearly all the gold is lost in the tailings, with about 15 oz. of mercury per ton of ore treated.

The loss of silver by amalgamation, working with ores considered suitable for that process, has been found to vary in Germany from 5 to 10 per cent. of the contained quantity.*

With the Comstock silver ores in America the loss is 12 per cent. by barrel amalgamation, whilst with the same ores by pan amalgamation the yield never exceeded 80 per cent., seldom 75 per cent., with a general average of 66 per cent.†

At the Port Phillip Works at Clunes, Mr. Latta reports that the average loss of gold by amalgamation in a period of seven years was 6 dwts. 10 grs. per ton, the highest loss being 7 dwts. 15 grs., the lowest 4 dwts. 8 grs., the pyrites being free or nearly so from copper and lead.‡

In treatment by fusion it is found at Kongsbeck in Norway, that after repeated fusion slags carry away 1 oz. 2 dwts. of auriferous silver per ton; and in Lower Hungary by a similar process the loss is in the slags 1 oz. 12 dwts. per ton, besides a loss of 3½ per cent. of the total silver in the smoke.

Rivot says: "The yield of gold and silver from pyritical ores does not exceed 65 per cent. of the assay, which is itself open to losses. According to many synthetical experiments, the loss is greater in assays of richer than of poor ores, amounting always to more than 30 per cent, and with fahlore and ores containing arsenical pyrites to more than 50 per cent. The loss incurred when working on a large scale is less than in laboratory assays.

* Watt's Dictionary of Chemistry, article Silver.
† S. A. Phillip's Mining and Metallurgy of Gold and Silver.
‡ Trans. R. Soc., N.S.W.

The difference between the yield on the large scale and the percentage by assay may exceed 30 per cent., even when the metallurgic method is quite perfect; but as the American methods are far from perfect, the difference is still greater.*

Many of the trials made during this investigation yielded negative results, and in others the yield of the precious metals was so small as to be of no practical value, and I shall therefore only give an outline of the methods adopted with a few results selected from numerous experiments.

The quantity of material operated on in all cases was 3,667 grains, from which quantity one-tenth grain represents 1 oz. per ton.

The first process which suggested itself for the extraction of gold was to take advantage of the solubility of sulphide of gold in solutions of alkaline sulphide, for if this could be effected it would render the roasting of the ores unnecessary.

In 1859, Henderson included in his patent for the extraction of copper, a process for extracting gold as sulphide. His directions are that the pyrites be fused to obtain a matt which is to be fused with two parts of salt cake (crude sulphate of sodium), and the matt run into pigs. These placed in water crumble to pieces; and the gold is obtained in solution, whence it may be recovered by precipitation with an acid.

In 1868, a process was patented in America for the extraction of gold by "sulphur and its salts," but of this I have no details.

The first experiments were made by treating portions of each ore with solution of sulphide of sodium containing a slight excess of sulphur. The experiments were varied in concentration of solution, in time of digestion from one to seven days, and in temperature, some being conducted at ordinary temperatures, others at 212° F. Twenty experiments were made altogether, and in no case was a trace of gold obtained on neutralizing with acid, filtering off the precipitated sulphur, and igniting. From arsenical pyrites much arsenic was obtained in solution.

Henderson's process was tried with Mariner's Reef ore, proceeding exactly according to his directions, but although the regulus disintegrated in water as described by him, I could not, in two trials, obtain any gold in solution. This process was modified, with equally unsatisfactory results, by fusing with sulphide of sodium, by fusion with sulphate of sodium and charcoal, and by heating finely powdered ore to a dull red with sulphite of sodium, without fusion.

The extraction of gold from its ores as chloride was proposed by Price, who, in January, 1857, patented a process in America for the extraction of gold from its ores by fusing them with sulphide of iron, and treating the regulus with aqueous chlorine

* *Rivot Ann. Min.* [6] VII. 1. *Watt's Dict. Chem., Second Supplement, p.* 572.

or an acidified hypochlorite. This introduced a source of difficulty, as the chlorine would have to convert the sulphide into ferric sulphate before any gold could be obtained in solution.

Ziervogel proposed treating roasted pyrites with chlorine, and his process was used at Chemnitz.

This process was afterwards patented in the United States by G. F. Deetken, in 1863, and has been used with tolerably satisfactory results in California in two establishments. The process is there carried out as follows:—The concentrated pyrites are subjected to a thorough calcination, and when sulphurous anhydride ceases to be evolved, the residue is withdrawn from the furnace and cooled. It is then sprinkled with water, and turned over several times until uniformly damped, the exact condition in this respect being a matter of considerable importance. It is then placed in a large wooden vat, having a false bottom, and chlorine gas from a generator is admitted below until it is seen floating above the material. The tank is then closed, the current of gas stopped, and the whole left at rest for ten or twelve hours, when the cover is removed and water is run on. This dissolves the chloride of gold formed, and the solution is run into earthenware or glass vessels, where the gold is precipitated as a bronze-black powder by the addition of a solution of ferrous sulphate.

As it had been found that gold alloyed with much silver was not readily attacked by chlorine from the chloride of silver formed encrusting the granules, Patero and afterwards Rösner proposed the use of chlorine dissolved in a concentrated solution of salt.

The disadvantage of the chlorine method of extraction is, that with ores containing copper, the whole of that metal has to be removed before the chlorine becomes available, and also all the sulphur which otherwise becomes first oxidized to sulphuric acid.

With a view to removing the copper, I carefully roasted a quantity of ore in a muffle, at a dull-red heat, with constant stirring for seven hours, and extracted the residue with water and sufficient sulphuric acid to convert all oxide of copper into sulphate. The dried residue was found to contain 1·5 per cent. of sulphur, and I therefore recalcined the whole for seven hours longer, and extracted the copper as before, when the sulphur was found to be reduced to 0·46 per cent. A similar result was obtained in successive trials, and as this amount of sulphur would require as much chlorine, as upwards of 3,300 ozs. of gold per ton, a more perfect method of getting rid of it was evidently required.

Another portion of ore was therefore partially calcined, cooled, and damped with brine, and the whole again calcined until fumes were no longer evolved.

The residue extracted with water and acid as before was found to contain 0·12 per cent. of sulphur and traces only of copper.

On assaying a portion of the residue, it was found to contain—

Gold ... ... 3 oz. 14 dwt. 8 grs. per ton.
Silver ... ... 39 oz. 18 dwt. 14 grs. „

A portion was ground up with mercury and sufficient water to make it of the consistence of thick cream, in which the mercury was well broken up for an hour, and afterwards carefully washed, the tailings being gone over as often as any mercury was found. This yielded—

Gold ...1 oz. 0 dwt. 5 grs. leaving 2 oz. 14 dwt. 3 grs.
Silver...6 oz. 16 dwt. 10 grs. „ 33 oz. 2 dwt. 4 grs.

Another portion, shaken up with a solution of salt and pieces of iron to decompose the chloride of silver, and the residue ground up as before, yielded—

Gold ... 1 oz. 1 dwt. 0 grs. leaving 2 oz. 15 dwt. 8 grs.
Silver...34 oz. 3 dwt. 5 grs. „ 5 oz. 15 dwt. 9 grs.

These results showing that even after the almost complete removal of sulphur, or at all events what would be considered complete on the large scale, the greater part of the gold present was untouched by the mercury, I proceeded to examine the effect of chlorine, of which I give the following as typical results:—

A portion treated with chlorine gas exactly as above described yielded gold, 16 dwts. 10 grs., leaving 2 oz. 17 dwts. 22 grs.

A portion treated with ¾ oz. of calcium hypochlorite and sulphuric acid with sufficient water shaken up in a bottle for twenty-four hours (it then smelt strongly of chlorine) was filtered through an asbestos filter, the residue well washed, and the gold precipitated—yielded 1 oz., leaving 2 ozs. 14 dwts. 8 grs. The dried residue was found to be free from sulphur.

A portion mixed with brine and the same quantity of re-agents as above and otherwise similarly treated, yielded gold 1 oz. 2 dwts. 5 grs., leaving 2 ozs. 12 dwts. 3 grs. The residue digested with water containing ½ oz. hyposulphite of sodium, the solution acidified and treated with sulphureted hydrogen, gave—

	ozs.	dwts.	grs.
Gold	0	3	0
Silver	22	14	19

Roasted arsenical pyrites, treated with hypochlorite of calcium and sulphuric acid as above gave—gold 11 ozs. 15 dwts. 5 grs., leaving 2 dwts. 19 grs. Roasted iron pyrites similarly treated gave—gold 5 ozs. 1 dwt., leaving 5 dwts. 3 grs.

The two last results show that with these simple pyrites the treatment with hypochlorite and acid gives very fair results, and this being a process involving no troublesome apparatus it might be sometimes applied with advantage.

It is difficult to account for the fact, that in the case of the more complex mineral the chlorine even in large excess exerts so little action on the gold, and that when all the copper has been removed previous to treatment; but in every trial similar results were obtained. It seems probable, however, that the state of aggregation of the metal has some influence on its solubility in chlorine, and that as a mispickel dissolves gold, it was therefore obtained in the residue in a finely divided state, less so in the iron pyrites residue, and least divided in the complex ore. In the last, mere traces of gold were obtained by re-treating the residues from the first treatment by chlorine.

The only other salts of gold which possess sufficient stability to render their use possible for its extraction are the auricyanides of the alkali metals and bromide of gold. Bromine would, however, be more expensive and more troublesome to use than chlorine, and moreover in one or two trials gave me smaller results than were obtained by chlorine. Skey* has described a method of testing for gold by the use of bromine water, and also with tincture of iodine. I have been unable to obtain any reaction either with tincture of iodine or with solution of iodine in iodide of potassium, which, considering the unstable character of the gold iodides, is scarcely to be wondered at.

Prince Balgration and Elsner† have observed that precipitated gold is soluble in cyanide of potassium if exposed to the air, and the latter says also in ferrocyanide of potassium. A patent was applied for in America in 1868 for the use of cyanide of potassium for the extraction of gold from its ores, but I have no particulars of the process. It seemed to me, however, that the high price of this salt, its instability when exposed to the air and in solution, and its extremely poisonous properties, precluded its use for this purpose. On trying the reaction between precipitated gold and cyanide of potassium, I found that it was extremely slow if the gold was at all dense. In presence of alkaline oxidizing agents, however, I found that the solution of the gold was sufficiently rapid. Thus, on standing over night, the quantity of gold and cyanide of potassium solutions being similar in each case—with the cyanide alone, traces only of gold were dissolved, but with the addition of calcium hypochlorite, ferrocyanide of potassium, or binoxide of manganese, all the gold was dissolved; with chromate of potassium, a small quantity; with permanganate of potassium, none.

With ferrocyanide of potassium alone I did not obtain any gold in solution after standing some days, but I thought that with suitable oxidizing agents it might be obtained in solution according to the equation—

$$4Au + 2K_4FeCy_6 + 7O + 4H_2O = 4AuCy_3 + Fe_2O_3 + 8KHO.$$

* Chem. News, XXII, 245. † Watt's Dict.: Cyanides of Gold.

In the cold, however, with the exception of ferricyanide of potassium, none of the above oxidizing agents had any effect, but heated to 212° Fah. the reaction with all of them was sufficiently rapid, and I found that this was also the case with permanganate. This reaction promised to be of considerable value, as the gold and silver would both be obtained in solution, from which the former could be precipitated by filtering the hot solution through finely divided metallic silver, of which an equivalent quantity would be dissolved, which, with the silver originally present, could be precipitated as sulphide. By treating the solution with ferrous hydrate, the cyanide of potassium could be retransformed into ferrocyanide, which has the important advantages of being exceedingly stable and non-poisonous. I found, however, that copper in any form precipitated both gold and silver from the solution, or at all events that these metals were not dissolved until the copper had all gone into solution; also, that if the copper was present as sulphide, the silver was transformed into sulphide which is insoluble. Any copper dissolved cannot be precipitated as sulphide, but I found that it could be removed by digesting the solution with ferrous hydrate, the solution being kept alkaline.

A portion of roasted arsenical pyrites was digested at 212° for twelve hours with ¼ oz. ferrocyanide of potassium, 32 grs. oxide of manganese (20 lbs. per ton), and sufficient water made alkaline by soda to make a cream—the solution yielded 9 ozs. 8 dwts. 19 grs. gold per ton, leaving 1 oz. 9 dwts. 15 grs. This was the best result obtained with this pyrites, the yield with other oxidizing agents and by more prolonged digestion being all somewhat lower.

With Mariner's Reef pyrites trials were made with each oxidizing agent in succession, the duration of the digestion being varied from twelve to fifty-six hours; whilst with the soluble oxidizing agents the quantity used was in some cases little over the theoretical amount, and sometimes ten times as much. In some of the experiments all the oxidizing agent employed was added at once, in others at successive intervals; and I found that after four or five times the theoretical quantity had been added, a further increase had little or no influence on the result. With binoxide of manganese, on the other hand, from thirty-five to forty times the theoretical quantity gave the best results. The material used had been roasted with salt and extracted with acid, and contained so little copper that 50 grs. digested with nitric acid, the solution made alkaline by ammonia, and made up to 50 CC, had only a faint colouration in a cylinder 3 inches deep. It contained—

	ozs.	dwts.	grs.
Gold	8	0	19
Silver	49	11	5

and yielded from 3 ozs. 12 dwts. to 5 ozs. 1 dwt. of gold, and from 46 ozs. to 46 ozs. 3 dwts. of silver per ton. This showed that all the silver which had been converted into chloride during the roasting was obtained in solution as cyanide. With the gold, on the other hand, all the results showed that with complex pyrites a portion only could be obtained in solution either in mercury or in water as cyanide or chloride, whilst none could be obtained as sulphide.

There being therefore no method by which the precious metals could be removed and the base metals left, it remained to fall back on one of the first principles of metallurgy, viz., to remove the base metals at the earliest stage possible, and leave the precious metals as a residue. In ordinary metallurgic operations this end is attained by dressing and successive smeltings. I however arrived at the conclusion that smelting was not a desirable process, as it is expensive and the gold and silver would at last be found alloyed with a large quantity of copper, whilst considerable quantities of these metals would be lost by volatilization and in the slags. These losses have been found elsewhere to be large, even when tested against the usual assay, which as Rivot observes is itself open to losses. That the loss of gold by any process involving smelting must be considerable is evident, when we consider that glass will hold a large amount of gold in solution. Thus, calculating from the quantity of gold used to form ruby glass, which is perfectly colourless when first melted, I find that it contains 10·88 oz. of gold per ton, imitation topaz 8·21 oz. of gold per ton, imitation garnet 27·18 and 46·33 ozs. per ton, by two different receipts. The gold is added in the form of purple of Cassius, that is, finely divided metallic gold mixed with oxide of tin; this usually contains 30 per cent. of gold which I have taken in calculating the above numbers, or of chloride of gold—an oxidizing agent being added at the same time. In smelting operations the ferric oxide would act as an oxidizing agent, and when once in solution it seems improbable that any practicable amount of smelting in presence of other metals would reduce and collect all the gold.

Thinking, however, that in spite of these objections a process of smelting was the only one which was likely to be successful, I turned my attention to the removal of the copper, so that I might obtain it separate from the gold and silver. Although many wet extraction processes have been used with success elsewhere, none of them appear to be quite suitable to the circumstances obtaining in these colonies. Perhaps the most successful has been the Longmaids' process as improved by Henderson, and so far as the recovery of gold and silver are concerned by Claudet. Worked in Great Britain, it has rendered available immense quantities of copper ores too poor to be treated by any

other method; but there salt costs from 10s. to 15s. per ton, whilst here it is seldom less than £3. There scrap iron is cheap, here if consumed in any quantity it would be very expensive, whilst inland carriage would immensely add to the cost of both. Again, in Great Britain the sulphur in the ores being used for the manufacture of sulphuric acid, it pays the whole or the greater part of the mining and carriage and the whole cost of the preliminary preparation and roasting, whilst the residual oxide of iron free from copper and sulphur is nearly of the value of hæmatite for fettling puddling furnaces; here both would be valueless.

With regard to Claudet's process for extracting the small quantity of gold and silver obtained in solution along with the copper by precipitation with iodide of zinc, the very small cost of which (9d. per ton of ore) has been noticed in the report of the Victorian Commission appointed to inquire into the treatment of pyrites, and others, I may note that this is only the *additional* cost of extracting those metals beyond that incurred in extracting the copper. It is only applicable to ores containing minute quantities of gold, and besides it is requisite that the whole of the copper be in solution as cupric chloride, as otherwise cuprous iodide is precipitated. As the formation of cupric chloride involves the use of more salt and its precipitation of more iron than cuprous chloride, the process has been abandoned in many places where tried.

As the formation of sulphate of copper during the calcination of pyrites is believed to take place in two stages, represented by the equations—

$$CuS. + 3O = CuO. + SO_2, \text{ and}$$
$$3CuO. + SO_2 = CuSO_4 + Cu_2O.,$$

I tried whether the addition of successive portions of raw ore would not gradually convert the greater part of the copper into sulphate during the roasting. After well roasting a quantity of pyrites, I extracted the sulphate formed with water from a sample; this was then dried, and the copper present as oxide was dissolved by dilute hydrochloric acid, and its amount determined. It was found to be equal to 6·54 per cent. of copper.

To 700 grains of the remainder (from which the sulphate had not been extracted), I added 40 grs. of fresh pyrites and roasted sweet at a dull-red heat in a small muffle, which took about an hour, treated a portion as before, and found the copper present as oxide to be 6·01 per cent. The remainder was again made up to 700 grs. with once-roasted ore, 40 grs. raw pyrites added and roasted sweet, when other 40 grs. was added and the calcination continued until complete, when the copper present as oxide was found to be 4·79 per cent. The oxide was thus steadily reduced, but the process was evidently too slow to be of use practically.

I then calcined 400 grs. of pyrites, mixed the residue with 200 grs. of raw ore and again calcined, then added 100 grs. of raw ore, and continued the operation until fumes were no longer evolved, when the residue was found to contain 6·46 per cent. of copper as oxide. This process was therefore of no value; but I noticed that after each addition of pyrites considerable quantities of white vapours were evolved, and as the ore contained but little arsenic this could only arise from the formation of sulphuric anhydride. I therefore proceeded to determine how much sulphuric acid could be obtained by calcining a mixture of raw pyrites and roasted residue.

A combustion tube was fitted with a smaller tube leading through water in a Woolfe's bottle, the second neck of which was connected with an aspirator, and mixtures of raw and roasted pyrites were heated to a dull-red in the combustion tube, a current of air being maintained through the whole apparatus, and the ore occasionally stirred with a bent wire. In this arrangement however I found that a large quantity of the white fumes escaped condensation, and I therefore substituted for the Woolfe's bottle a flask containing a small quantity of water, the exit tube of which was connected with an inverted Liebig's condenser. The water in the flask was kept gently boiling, and I found that by this arrangement the condensation was very good. 100 grs. of raw pyrites containing 37·86 per cent. of sulphur, mixed with 50 grs. of the same which had been well roasted and the copper extracted, was thus treated. The residue in the tube was digested with hydrochloric acid, and the sulphuric acid formed determined in one-half of the solution, whilst in the condensed water sulphuric acid was determined in one-fourth :—

½ of residue gave barium sulphate... ...	31·65 grs.
¼ of condensed water gave barium sulphate	35·82 „

calculated on the 100 grs. used, this gave—

Sulphuric acid in residue =	8·68 sulphur.
„ „ water =	19·86 „
Total...	28·54 sulphur.

Similarly, 100 grs., with 20 grs. residue gave—

½ residue, barium sulphate	31·69 grs.
¼ water „ „	34·59 „

which calculated on 100 grs. used gave—

Sulphuric acid in residue =	8·70 sulphur.
„ „ water =	19·00 „
Total...	27·70 sulphur.

On reducing the roasted ore to 15 grs., a smaller return was obtained; but these results showed that by proper management nearly three-fourths of the sulphur present in the ore could be

obtained as sulphuric acid, either in the free state or in combination with copper and iron—this quantity is nearly sufficient to dissolve both the copper and iron, the latter as ferrous sulphate, the theoretical quantity required with the ore operated on being 29·67 per cent. of the sulphur converted into sulphuric acid—and opened at once a prospect of the attainment of the desired result.

As it was probable that such a result would not be attained on a large scale, I proceeded to examine the action of aqueous sulphurous acid, and found that by treating ore calcined at a low temperature therewith, a considerable quantity of sulphate of iron was obtained in solution along with the sulphate of copper; also that, as Muspratt had observed, aqueous sulphurous acid readily attacks finely divided metallic iron, forming sulphite and hyposulphite.

The form the process now presented itself in, was, to calcine the ore at a low temperature and extract the sulphates of copper and iron formed with the mixed sulphurous and sulphuric acids formed during the roasting, then to reduce all the iron to the metallic state and remove it in the same manner, when the gold, silver, antimony, and lead would be left. The only points that remained to be decided were, how to reduce the iron to the metallic state, and to obtain the copper from solution.

The reduction of the iron was necessary, because the sulphuric acid obtained would be too dilute to act on the ferric oxide, and the quantity would be insufficient to form ferric sulphate, whilst sulphurous acid has no action on the ferric oxide. I first attempted the reduction of the iron by hydrogen at a faint-red heat, which gave the metal in a form very suitable for the action of sulphurous acid. This had to be abandoned, however, on account of the cost and the danger of explosion. Coal-gas reduced the iron readily, but at a low temperature much finely divided carbon was deposited amongst the iron, which rendered wetting it difficult, and the powder was very pyrophoric. Reduction by finely ground carbon at a low-red heat, I found could be so managed as to obtain the iron as a metallic powder which was readily attacked.

For the removal of the copper from solution the use of metallic iron had to be abandoned, on account of the quantity required to precipitate it from its solution as sulphate, which on the large scale is found to be about three times the quantity of the copper precipitated. As it would be advantageous to recover some of the sulphuric acid, the use of sulphuretted hydrogen presented itself, but after repeated trials the exceeding bulk of the precipitate presented an obstacle which on any considerable scale would be insuperable, and has indeed been found to be so where tried.

I therefore determined to try whether it could not be recovered by crystallization; and the result of many trials showed that by taking a cold saturated solution of sulphate of copper, and, after adding sulphuric acid, saturating it with sulphurous acid, I had a solution which would render all but traces of the copper and sulphate of iron in well-roasted pyrites soluble without dissolving any. In fact it deposited crystals on being mixed with the calcined ore from the sulphates of copper and iron withdrawing crystallization water. By then washing by displacement with a solution of sulphate of copper saturated in the cold made boiling hot as long as the escaping solution deposited crystals on cooling, the residue was obtained saturated with a solution of sulphate of copper which would not deposit crystals. This solution could be so displaced by water equal to one-half the bulk of the residue as to leave only 0·67 per cent. of copper in a soluble form, whilst if an equal bulk of water was used the copper left was ouly 0·12 per cent. Practically, therefore, it was possible to remove all the copper in such a way as to deposit it in crystals without increasing the bulk of the fluid, so that no evaporation would be required.

The mixed crystals of sulphate of copper and sulphate of iron evolve on calcination large quantities of sulphurous and sulphuric anhydrides, which could be condensed in a solution of sulphate of copper and used to extract a future lot.

I now proceeded to treat twelve pounds of the dressed pyrites of which an analysis is given above. One-half pound at a time was calcined in a muffle having the draft-holes closed with clay, and an iron door fitted at the front. From the back of the muffle an iron pipe led into a small upright leaden tower fitted with moveable perforated leaden trays, so that the evolved gases passing over the trays in succession finally escaped to the chimney at the top. On the upper tray water was allowed to drop through a trapped tube, and dripping from tray to tray flowed off through a pipe at the bottom, whilst steam was admitted at the bottom in sufficient quantity to keep the lower half of the tower warm. Half a pound having been calcined, the copper and sulphate of iron was extracted with water containing sulphuric and sulphurous acids, the residue was reduced with carbon at a dull-red heat, and the metallic powder being spread on the trays was subjected to the action of the gases from the second half-pound, the residue from which was treated as before, and to the gases from the third and so on, until the whole was operated on. The last half-pound was, after reduction, treated with dilute sulphuric acid, my parcel of ore being exhausted. The whole of the soluble matter was then extracted with water, which reduced it to a small bulk which was almost entirely free from iron but contained a small quantity of copper as sulphide.

It was therefore calcined on an iron tray, and the copper extracted. by dilute sulphuric acid. The dried residue weighed 21½ ozs., and being melted with some oxide of iron and a little carbonate of sodium and carbon gave a brittle button weighing 5¾ ozs. To remove the antimony, as being the most convenient for laboratory use, this button was fused with carbonate of sodium and nitrate of potassium, which left a button weighing 3¾ ozs., which was cupelled to obtain the gold and silver. These were parted with nitric acid; the finely-divided gold, folded up in lead foil, was again cupelled, giving a button weighing 37·54 grs. The silver was precipitated as chloride, to which was added a small quantity precipitated from the copper solution, and on fusion with carbonate of sodium gave a button weighing 158·65 grs. The first cupel bottom was ground up and fused with sodium carbonate, and charcoal, when it gave a button of lead weighing 2 ozs.

The mother liquors from the sulphate of copper crystals were evaporated to dryness (this evaporation was necessary in the experiment to recover all the copper, but would be unnecessary on the large scale, the mothers being then used again and again indefinitely so long as there was fresh material to be extracted), and the whole of the sulphate was dried. One-half was heated to a full-red heat, to reduce the sulphates to oxides; the other half was heated to a dull-red to decompose the sulphate of iron, then mixed with carbon and a little sand and heated to fusion, when the oxides were added and metallic copper obtained, which with a prill obtained on re-fusing the slags weighed 31¼ ozs.

With the exception of using extraneous sulphuric and sulphurous acids for the extraction of the copper and sulphate of iron formed during the calcination, the whole process was carried out as nearly as practicable in a laboratory as it would be on a large scale. There are good working methods for smelting out the lead and antimony with the gold and silver, and for separating these metals, which I need not detail. The large quantity of sulphate of iron extracted from the roasted pyrites by the use of sulphurous acid would give on calcination more than enough sulphuric acid to extract the oxide of copper formed. The average quantity of sulphate of iron obtained from this ore was about one-half the weight of the sulphate of copper produced.

To conclude, the yields obtained from 12 lbs., as compared with those shown by analysis and assay, were—

	Analysis.	Yield.
Copper	17·02 per cent.	16·5 per cent.
Lead	2·01 „	1·04 „
Antimony	3·9 „	Not recovered.
Silver	62 ozs. 9 dwts. 18 grs.	61 ozs. 13 dwts. 22·7 grs.
Gold	12 ozs. 10 dwts. 0 grs.	14 ozs. 11 dwts. 23·2 grs.

These numbers are very satisfactory; and, although it is scarcely to be expected that the results would be equally satisfactory working on a large scale, it seems more than probable that returns better than those by any other process would be obtained.

Whilst experimenting on the removal of copper from solution, I found that this could be conveniently done by filtering the slightly acid solution through ground matt obtained from the same ore by simple melting. This method of separating copper from solution may be of advantage in treating poor copper ores or pyrites containing small quantities of copper; but it is obvious that for ores in which gold and silver form an important constituent, it is not so advantageous as the process already described—as, firstly, the gold and silver, so far as contained in the matt used for precipitating the copper, would remain with that metal, and be lost; secondly, the sulphuric and sulphurous acids, which in the process above described are obtained by calcination of the sulphates of copper and iron, and are available for the extraction of roasted ore, giving with those evolved during the roasting a superabundant supply of acid, would be lost. Neither of these objections would, however, have any force if copper were the only metal to be extracted. The matt obtained by simply melting poor cupreous pyrites, with the addition of sufficient roasted ore to form a flux for the silica present, consists of sulphide of iron containing more or less sulphide of copper; and by filtering through a bed of this matt the solution of sulphate of copper obtained by calcining and extracting a larger portion of the ore, the copper is deposited, whilst the iron goes into solution. I expected to find that the whole of the iron could be thus removed from the matt which would be converted into sulphide of copper, but found that in all cases the action stopped short of this. The percentage of copper in the treated matt varied from 30 per cent. to 33 per cent., approaching therefore to copper pyrites, which contains 34·6 per cent. of copper. From this residue refined copper could be made in three operations.

This method of treatment, as well as the one above described, for the separation of the various metals, have in common with ordinary copper smelting the advantage that no materials except those yielded by the ore are required, with the exception of fuel, water, and air.

In working ores on the large scale for the recovery of gold and silver by the process, which I have founded on the experiments, of which I have given a brief *résumé*, it is advisable to obtain the sulphides as free as possible from vein stuff before proceeding to the actual treatment. To this end the crushed ore may be washed when any free gold contained in the quartz may be recovered by amalgamation,

or in particular cases the ore may be subjected to a preliminary smelting. The method of getting rid of the quartz must depend entirely on the price of labour, fuel, &c., and the composition of the ore. I have found, on the one hand, that nearly all the gold and silver are obtained in a matt if it amounts to from one-half to two-thirds of the original ore, whilst if the matt is smaller both gold and silver are left to a considerable extent in the slags; but there are few ores which would give such a proportion of matt without preliminary dressing. On the other hand, ores containing sulphide of silver lose much of that metal by washing; the sulphide being exceedingly friable it is carried away in the slimes, which are often richer in silver than the original ore.

The method of treatment of the concentrated ore, or regulus, is the same whether the sulphides are rich in the precious metals or not, but requires variation according to—1st the presence or absence of copper; 2nd, the proportion of copper; and 3rd, the presence or absence of lead.

To begin with the simplest case, viz., with pyrites free from copper. The apparatus required consists of—1, a roaster, A; 2, a reverbatory furnace, F; 3, an arsenic flue, B (if the pyrites are arsenical); 4, a leaden combination chamber, C; 5, a leaden condensing tower, D; 6, a series of lixiviating tanks and coolers. It is best to construct the furnace, roaster, arsenic flue, converting chamber, and tower in one line, so that the waste heat from the reverberatory furnace heats the sole of the roaster and converting chamber. The reverberatory furnace is constructed in the usual manner, but the sole is made simply of brick, and flat, with an opening in the centre or side, *f*, through which the charge may be raked out into an iron hopper waggon, G. The roaster, A, is built as a muffle, with a sole of brick, or cast-iron plates laid at a slight incline, to facilitate the transference of the charges. At the lower end there is a depression of about six inches, forming a recess, E, which extends half-way over the reverberatory furnace, and has an opening, which can be closed with a slide, through which the contents of the recess may be at once transferred to the furnace. At the end of the roaster is an arsenic flue if required. Farther on is the combination chamber, built of sheet lead, supported by an external framing of wood; the sole is of sheet lead, supported on iron plates over the flue, *cc*. The sole is divided into eight stages, each of which is an inch higher than the one nearer the roaster. Beyond the combination chamber is a condensing tower, which may be built of brick, laid in a putty of clay and coal tar, or better, sheet lead, supported by an external framing of wood. The condenser is filled with coke or pebbles, supported on iron bars covered with lead, allowing a free space for the entry of the gases evolved in the roaster. Sur-

mounting the coke is a perforated sheet of lead, with suitable openings for the escape of the residual gases, which may be conducted by a pipe to the chimney. On the perforated lead plate water is delivered at intervals by a self-acting tumbler, kept supplied from a cistern. The water escaping through the holes in the lead plate is uniformly distributed over the coke, and trickles downwards, escaping over the sole of the combination chamber, flowing over each stage in succession, and from the lowest to a wooden cooler, whence it is again pumped to the cistern.

The roaster should have two or three small fireplaces at intervals underneath the sole, to get it to a working heat, which may be closed when this is attained, the flame from the reverberatory furnace, mixed with a sufficient quantity of air through openings in the flue, then supplying sufficient heat.

The roaster sole being heated to a dull-red heat, 2 cwt. of the dressed pyrites, or ground regulus, is mixed with from ten to fifteen per cent. of previously roasted ore, and charged into the upper end of the roaster, so that it occupies about 2 feet of the length, and spreads across the sole, which it should cover to the depth of one and a half inches. The ore soon becomes ignited, evolving sulphurous, sulphuric, and arsenious oxides. The last is condensed in the arsenic flue, and the two former pass through the combination chamber to the condensing tower, and are there absorbed by the descending water.

In an hour's time the charge is moved two feet to the left, and a second charge of the mixture is placed in the space cleared. At the end of another hour the first charge is moved two feet to the left, the second to the space cleared, and a third is introduced, and so on until at the end of twenty-four hours the sole of the roaster is covered. The upper part of the roaster should be at a very dull red heat, whilst the lower should be sufficiently hot to decompose any sulphate of iron formed.

On the sole of the recess E from 35 to 40 lbs. of coal dust, charcoal dust, or other carbonacious matter is now spread, and the calcined residue from the first charge is turned over on top of it, each charge in the roaster is moved downwards, and a fresh charge of mixture introduced. In another hour a similar quantity of carbon is spread on top of the charge in the recess, and the second charge is turned over on top, and so on until eight successive charges of roasted residue and carbon are in the recess.

The contents of the recess are then transferred to the reverberatory furnace, through the opening *e*, the whole is well stirred up and spread over the sole. The furnace is closed, and kept at a moderate-red heat for eight hours, the furnace being kept full of a smoky flame to assist reduction. The oxides are thus reduced to the metallic state, and the heat should be kept

so low as to prevent the reduced iron from agglutinating into masses. At the end of eight hours the reduced metal is withdrawn from the furnace at the opening *f*, into the hopper waggon G, which is immediately closed, so as to prevent access of air. The furnace is again charged from the recess, which has meanwhile been filled.

When the hopper is cool enough to be handled, the contents are rapidly transferred to a vessel containing water, best by placing the waggon over the vessel and withdrawing a slide in its bottom, so as at once to thoroughly wet and cool the contents.

One-eighth part, or thereby, of the cooled metal is now placed in the upper stage of the combination chamber, over which water from the condenser, charged with sulphurous and sulphuric acids, is flowing. In one hour the charge is moved to the second stage, and a second charge is introduced, and so on until in eight hours the chamber is filled, and that furnace charge exhausted. The metal is rapidly acted on by the acids, and converted into sulphate, sulphite, and hyposulphite of iron, but by the combined action of the air and water, assisted by the heat from the flue, the first largely predominates. The charge on the lowest stage is now removed, and may be at once lixiviated with water, but it is best to keep it for a few days in a moist state, to finish the conversion into sulphate. It is then lixiviated with water, which removes sulphate of iron (also zinc, nickel, and cobalt if present), and leaves a residue containing the gold and silver, mixed with quartz, excess of carbon, and free sulphur. The carbon and sulphur are then burned off, and the gold and silver separated from the quartz by washing, amalgamating, or otherwise. If the extraction of the sulphate of iron is effected with boiling water, and the liquor run into coolers, that salt may be obtained in a marketable condition; or the crystals being calcined at a dull-red heat yield a fine red oxide of iron suitable for painting, and sulphuric acid which may be condensed.

If the ores contain copper in small proportion only, the roasting, reduction, and solution of the iron are conducted precisely as above described, using, however, as little carbon as possible for the reduction, so as to obtain the residue nearly free therefrom. The copper is then found in the residue principally as sulphide. This residue is roasted at a dull-red heat, and the copper is extracted by treatment with condenser liquor and crystallization, as described below, the gold and silver being obtained from the residue as before.

Ores or sulphides containing much copper are roasted at a dull-red heat, the mixing with roasted ore, roasting, and condensation of the gases being conducted as before. The well-roasted ore is withdrawn from the furnace and cooled. The

cooled residue is then shaken into a lixiviating tank partly filled with a solution of sulphate of copper, containing sulphuric acid and sulphurous acid, obtained as below described; the mixture is allowed to digest, and treated with successive portions of the acid solution until the escaping liquor contains free sulphuric acid. The lixiviation is then carried on with a cold saturated solution of sulphate of copper from the coolers, which is made boiling hot in a leaden or copper boiler, until the specific gravity of the entering and escaping solutions is the same. The whole of the copper liquors are run into wooden coolers, where crystals of the sulphates of copper and iron are deposited. When the lixiviation has been carried as far as possible with the copper solution, it is drawn from the tank until it stands only an inch or so above the solid contents, and 12 inches of water are carefully floated on top, and the drawing off the copper solution continued from below until the water is only an inch above the solid contents, when a second wash is run on, and in the same manner a third if necessary. The copper liquors are run to the coolers as long as they mark above 20° of Twaddel, below that strength they are run to a separate tank to be used for the first wash of another lot.

If the ore contains silver, a little is found in solution in the copper liquor, and is separated therefrom by filtering it through a bed or beds of cement copper, or, better, of precipitated sulphide of copper, before running the liquor to the coolers. The silver is recovered from time to time by roasting the precipitate, extracting the copper by condenser liquor, and melting the residual silver.

The residue in the lixiviating tanks is drained, dried, mixed with one-fourth of its weight of carbon, reduced, and otherwise treated as above described, to obtain the gold and remaining silver.

The crystals of sulphates of copper and iron in the coolers are removed from time to time, drained and dried. One ton of the dried crystals is charged into the muffle furnace, fig. 2, B, and there exposed to a full cherry-red heat, so as to convert the whole of the sulphates into oxides. The sulphurous and sulphuric acids evolved are conveyed to the condensing tower, F, which is supplied with sulphate of copper solution from the coolers, slightly diluted with the weaker wash liquor by which the acids are condensed, and used for extracting roasted ore. When vapours are no longer evolved the calcined residue is removed from the muffle. A similar charge of dried sulphate is heated in the muffle furnace at C to a dull-red, so as to convert the sulphate of iron into oxide, and when fumes are no longer evolved the charge is raked out, mixed with 2½ cwt. of coal or charcoal dust, and charged into the reverberatory furnace, A,

where it is melted, when sulphurous and other gases are evolved causing the mass to boil. When boiling ceases the oxides from B are added to the charge, and the melting heat continued until the whole is in a tranquil fusion, when the slags are raked off and the rough copper run into moulds.

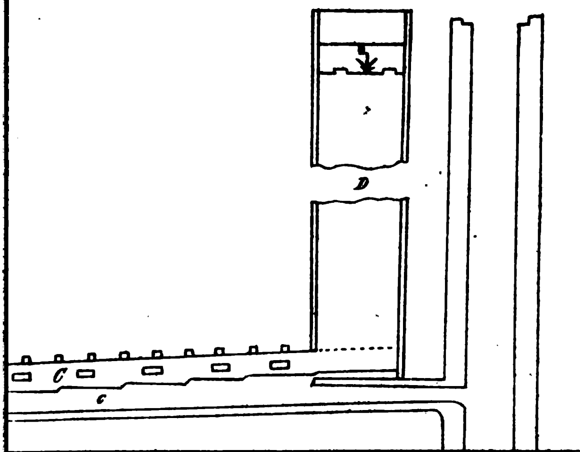
If the ore contains lead it is found in the residue containing the gold and silver; and if present in sufficient quantity the residue may be smelted, and the gold and silver recovered by cupellation.

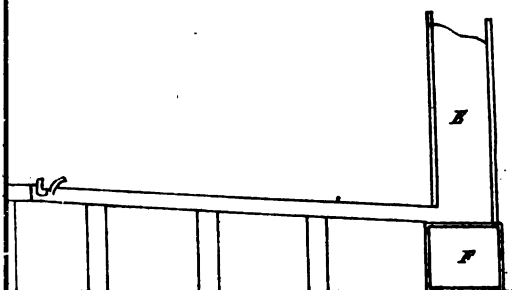
If not present in sufficient quantity to smelt, but still so much as to interfere with the amalgamation, the residue is roasted, treated with a little condenser liquor, washed, and the lead extracted with solution of caustic soda, when the gold and silver may be amalgamated. The solution of lead in caustic soda is mixed with sawdust or carbon, evaporated to dryness, heated strongly, and the carbonate of soda dissolved out with water, and again rendered caustic by lime, when the lead remains as an insoluble residue mixed with carbon.

The advantages of this mode of treatment are, that the sulphides are entirely got rid of, whilst if through inattention in the roasting some sulphides remain, only the small proportion that has escaped requires to be re-roasted, instead of the whole mass of ore as is usually the case. In the extraction of copper from the sulphides the whole of the copper may be obtained in the form of crystals, from which the copper may be recovered without evaporation of liquors; and in the whole of the operations, with the exception of smelting for copper, the temperatures are so low, that the cheapest materials may be used for the construction of furnaces. The temperature being low, the loss of silver by volatilization is reduced to a minimum, whilst there is absolutely no loss of gold, except through the careless spilling of the material. Lastly, as neither salt, iron, or other material is consumed in the process, a large source of expense in all previous wet methods of treatment is avoided; and the process is adapted for use wherever the ores are found.

[One diagram.]

nd other Metals, from Pyrites,





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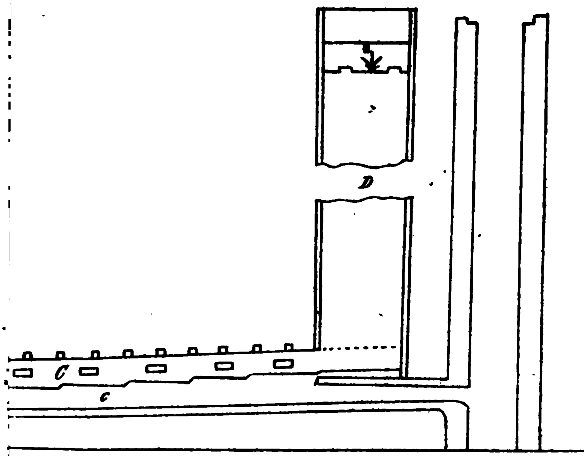

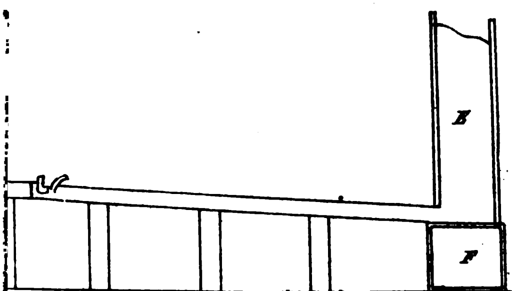

Palæontological Evidence of Australian Tertiary Formations.

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At a recent meeting of this Society I read a paper on "Australian Tertiary Geology," on which I proposed to prepare at some future time a complete list of our described Australian Tertiary fossils. This task has occupied a good portion of my leisure since, but it will be yet some time before it is completed, as I have been induced by Prof. Tate to delay the publication until some work he has in hand on some of our Tertiary Gasteropoda is published. In the course of its preparation the question of the age or position of our Tertiary formations has come very prominently before me. I do not mean to say that I have been able to arrive at any very definite conclusion on the subject, for a comparatively certain or permanent conclusion may be very distant from us; but I think the Palæontological evidence has never fairly been collected together—the data are scattered in various publications, and I think I can hardly do better than group them, so that the facts may be seen and their weight better appreciated. My knowledge of some of the beds and most of the fossils, and of the existing fauna, extends over many years, and it may be as well for me to try to arrange them, as a help to others who may come after me.

I said in my former paper that it was not easy to judge by the percentage system, as our knowledge of the existing fauna is so imperfect, yet I think, upon consideration, that the imperfection of this knowledge has been exaggerated. We do know a great deal of the Mollusca, the Echinodermata, the Polyzoa, and the Brachiopoda; for the Echini alone we may say our knowledge cannot be much extended; the Corals, too, have been tolerably well worked out. So that after all there is quite material enough to form an opinion. Well, then, my object is to show in this paper what that material is, and what its affinities are. With this view, I shall examine what fossils we have in our Tertiary rocks which are still existing, and what differences there are (if any) between their present habitats and their former ones. I shall next inquire what are the extinct fossils, which are found elsewhere as fossils, and where they are found. I shall then inquire into the relations of those fossils which have no living or

fossil representatives elsewhere. This inquiry means, Where do we find anything *like* our fossils? The solution of these questions, as far as our knowledge goes, will materially help to clear the ground of at least some of the obscurity which at present rests upon it.

But, before I do this, I must define what I mean by our Tertiary formations. I do not mean the raised beaches, or the more recent Pliocene formations. The evidence of all these is clear and unquestionable. I mean only the great Tertiary formation which extends, with the interruptions I have already described, from the river Murray to Gipps Land, and from Tasmania some distance inland in South Australia. In this formation there are many subdivisions, as I have already indicated, and some no doubt are much older than others. They are spoken of as one formation by European geologists; but the Pliocene of Italy, the Miocene of Vienna, Touraine, and Malta, and the Eocene of Paris and London, are not more widely separated than the Murray and Tasmanian beds, the Muddy Creek, Western Port, Onkaparinga, and Australian Bight. I shall deal principally with the Tertiary rocks which are represented in Victoria, in the south-eastern district of South Australia, and North Tasmania. There are various subdivisions in these rocks. They have been generally classed as Cainozoic by Professor Duncan, the learned President of the Geological Society. They are variously regarded as Lower Miocene and Pliocene by geologists in Australia. A succession is established by the Victorian Geological Survey, and to this I may say that I adhere: regarding the Tasmanian beds as the equivalents of the Muddy Creek and Geelong formations, and regarding the Mount Gambier limestones and the Polyzoan beds at Cape Otway as the uppermost of the series.* As I am not in a position to say anything of the fossils of the Aldinga beds and those of the Australian Bight, I must not be understood to include them in this examination; but I may state that it is probable that the Bight strata are the equivalents of the Murray cliffs, and I regard the Aldinga formation as lower than anything we have in Victoria or South Australia.

I now proceed to examine the recent species found as fossils in our Cainozoic rocks. I may include generally the far greater portion of the *Foraminifera*. I am not aware that many purely extinct forms have been discovered. They are tertiary in character. Knowing the wide vertical and horizontal range which these species have, we must not expect any conclusive evidence from them; and even if we would, they have never been carefully examined. *Amphistegina vulgaris* is very abundant in the Muddy Creek beds, and of large size. The following were determined

* Prof. Tate thinks he has reasons for believing that the Mount Gambier limestones are older than the Muddy Creek and Geelong beds.

for me by Professor Rupert Jones, many years ago:—*Polymorphina lactea*, *Textularia pygmea*, *T. agglutinans*, *Globigerina bulloides*, *Cassidulina oblonga*, *Rosalina Bertholetiana*, *Rotalia ungeriana*, *R. Haidingeri*, *R. reticulata*, *R. rotula*. There are no *Nummulites* or any of the characteristic forms of our Eocene beds.

Turning now to the Polyzoa, we must say in this case also that a careful examination is wanting. A *Retepora*, very nearly allied to *R. monilifera*—if not identical with it—is common at Mount Gambier, so is the existing *Salicornaria sinuosa* (Hassal), and *Cellepora pumicosa* (Busk). Some of the *Escharidæ* have been doubtfully referred to existing species; but it must be remembered that by far the larger portion of our living Australian Polyzoa are of families which would inevitably be destroyed ere they could be entombed in our rocks. They are jointed with horny joints in a single or multiple series of cells, and these horny joints would rapidly perish, and thus cause the destruction of the whole. It is among the *Lepralia* that I should look for the most important results, for these are well preserved, and are abundant in the living and fossil states, yet neither have received much attention. I am somewhat familiar with the various forms of *Membraniporæ* living on our southern coasts, and I have carefully searched for fossils like them at Mount Gambier, but without success. If ever there were a field where a careful observer might make most useful researches and extend our knowledge, this is one. It is, I may say, quite untrodden, and the facility with which the study could be approached, and the beauty of the forms to be dealt with, ought to make it equally attractive. As far as my own observations extend, I should say that we have but a small portion still existing of those which were likely to become fossils.

Referring to the corals, because that is the order which is most convenient, for I need hardly state that in point of organization they rank below the Polyzoa, it is singular that, while the Mount Gambier formation abounds in Polyzoa, Corals are almost entirely absent. In fact, I can remember none except a rare cast of *Placotrochus* occasionally. But at Muddy Creek, Geelong, and Table Cape, Tasmania, they are numerous. Now the existing forms among all these localities are only four in number, namely, *Flabellum candeanum*, *F. distinctum*, *Deltocyathus italicus*, all Edw. and Haime, and a new species of the genus *Sphenotrochus*, which I have named *Sphenotrochus variolaris*. The first is a well known form in the Red Sea and off the coast of Japan; the second occurs at Japan and in the Miocene fauna of Touraine. Both these localities are tropical, and very different from the condition under which the same corals would have to exist were they flourishing in Australia in the localities where they are found as fossils. *Deltocyathus italicus*, Edw. and Haime, is another species

which still exists, that is to say a variety of it, but in the Carribean Sea, and it is also found in the Miocene formation of Europe. *Sphenotrochus variolaris* is only known hitherto on the east coast, and is rare. Now, out of about forty described fossil forms, and probably as many more undescribed, four existing is a very small proportion, and this let it be remembered only in very remote and tropical countries, and under totally different conditions, that is to say, surrounded by a totally different fauna from that which surrounds them now. We have in Australian seas at present about thirty forms of coral known as living, but hardly more than three of them are included in our Tertiary formations.

I will now deal with the Echini of the same beds. We have twenty-four well characterized species described from our Australian fossils. This probably includes two described by me in 1865, and described again by European palæontologists who had not seen my work, namely, *Echinolampas Gambierensis*, subsequently named *E. ovulum* by Laube, and *Brissiopsis Archeri.** See *Proceedings Philosophical Society, Adelaide*, 1865. Out of this number we have only three living species—*Echinanthus testudinarius* (Gray), *Echinarachnius parma* (Gray), *Schizaster ventricosus* (Gray). The first is a species with rather a wide range, being generally an Indian Ocean (Red Sea inclusive) and Pacific species, being found also at California. It is commonly tropical, but not at all uncommon at Port Jackson. In all my examinations of collections and specimens, extending over many years, I have never seen it from the south-west of Australia, or near where it is found as a fossil now. *Echinarachnius parma* is found, we may say, all over the world. I have seen specimens from almost every part of the coast, though it is more common within the tropics. *Schizaster ventricosus* is said to be Australian, but I have never seen a well authenticated specimen from Australia. It is not common in New Caledonia and some of the tropical islands of the Pacific. Thus we see, of our three living species, one is not now Australian; and, of the other two, one is not found in the same localities; and all are more properly tropical species, though they are sometimes found outside it.

Referring now to the Mollusca, we find the same paucity of living forms, and nearly all with a different habitat. As far as we know, the fossils still living are *Limopsis Belcheri*, *Pectunculus laticostatus* (Lamck.), *Corbula sulcata* (Linn.), *Cylichna arachis* (Quoy and Gaim), *Fissurella concatenata*, Crosse, *Ancillaria mucronata* Sby, *Liotia lamellosa*, mihi, *Dentalium lacteum*, *Limopsis aurita*, Sassi, *Trivia europea*, *Liotia discoidea*, Reeve, *Eulima subulata*, Donovan, *Syrnola bifasciata*, *Natica polita*,

* It appears that there is a peripetalous fasciole on this fossil, which removes it to the genus above named. I had described it as *Hemiaster*.

mihi. Of these, *Fissurella concatenata, Natica polita, Cylichna arachis, Liotia discoidea, L. lamellosa,* and *Syrnola bifasciata,* still are found living on the east coast of Australia, and near the beds where they are, found fossil; but they are not common, with the exception of *Cylichna,* which has a wide range. The European shells are perhaps more open to question. I would not like to give their identification as more than probable. The other shells are found now in very different places. *Corbula sulcata* occurs on the coast of Africa within the tropics, *Limopsis Belcheri* at immense depths off the Cape of Good Hope, *Pectunculus laticostatus* in New Zealand, but both the latter are found in St. Vincent's Gulf and N. Tasmania. We see thus that the proportion of living species is very small, not eight per cent., and that of these so few are found in the same localities and the rest so variously scattered that we can conclude nothing as to the habitat except that some of them are found in warmer seas, and only one in colder, that is *Pectunculus laticostatus. Dentalium lacteum* is an Indian shell. It is doubtful if *Ancillaria mucronata* was not described from a fossil. I have never seen a living specimen.

On the whole then, the living species are not eight per cent. of the actual number described. We have about 120 described mollusca (including Brachipoda), nearly thirty Echinoderms, about forty Corals, and say twenty Polyzoa. But of the sethere are not twelve in existence. This according to European standards would place our Tasmanian and Muddy Creek beds on a level with or even below the Upper Eocene; and if from this estimate of living species we reject the three recent Echini which are found in the Murray beds, but not in the beds mentioned above, we shall bring our percentage still lower.

I now address myself to the question of those fossils which are found in Australia in other Tertiary formations elsewhere. In the Polyzoa we have only one, which is the living species *Saliconaria sinuata* referred to above. Our Corals are represented sparsely in other strata. *Deltocyathus italicus,* Edw. and Haime, occurs in the Miocene of Europe, *Conotrochus M'Coyi* in the older Pliocene of Sicily, and *Balanophyllia cylindracea,* Mickelotte, in the Miocene of Tortonia. Few of our urchins are found among the fossils of other formations besides those which still exist, as I shall show further on. *Echinarachnius parma* was found by Mr. Darwin in a Tertiary deposit at Patagonia, whose age has not been determined. Among the mollusca there is scarcely any identity or at least no very satisfactory identity with extinct species in other deposits.*. At first sight many of our fossils have been referred to forms found in Tertiary deposits of Europe and America, but

* *Limopsis aurita,* Sassi, is not uncommon in our lowest beds. *L. insolita,* Sby and Hutton, is, according to Prof. Tate, a synonym.

in the end sufficient differences have been perceived to cause them to be regarded as distinct. In nearly every case these identifications have been with well known Miocene or Eocene forms. We may however take what Professor M'Coy has called the "mimetism" of our Volutes in the oldest of our Tertiary rocks as instances of at least quasi-identity with well-known Eocene forms of Europe. Some of our fossil Brachiopoda are extremely like described species from the Malta Miocene, but we have the very best authority, that of Mr. Davidson, for regarding them as distinct. Prof. Tate thinks that the Brachiopoda have no affinity with the Italian forms, though there is a similitude in some species. He looks upon them as unique in facies.

I shall now proceed to examine the question of the relations of our Tertiary fossils, that is to say, failing complete resemblance or identity, what fossils do they resemble the most, and what is the geological horizon to which those fossils belong? In dealing with this question, I must say a few words on what is generally recognized as the Mesozoic facies which the Australian fauna possesses. Unless we estimate this beforehand, we might be led astray as to the character of our extinct Tertiary fauna. And it is also necessary to refer to it to pursue another inquiry of considerable interest, which is—Do we find in our Tertiary rocks stronger and stronger Mesozoic resemblances as we go down, so that our present fauna may be said to be what is left of a very slow extinction of the Mesozoic fauna?

I need not dwell upon the evidence of our existing fauna, which is familiar to every naturalist; still I may say that it has been somewhat overstated. In the marine fauna it is slight; in the mollusca I know of nothing except our possessing some species of *Trigonia*. These are, however, very distinct from the Secondary forms. In the Tertiary beds we have three species. Two are like our existing species in trifling particulars (*T. acuticostata*, and *T. Howittii*—M'Coy), and one is very much like the middle Secondary forms (*T. semiundulata*—M'Coy). A very remarkable instance of a surviving ancient form, which is even palæozoic in character, is found in a large *Pleurotomaria* (*P. tertiaria*, M'Coy).* In the Aldinga beds of South Australia, which I think will be found older than any Tertiary beds of Victoria or Tasmania, and perhaps even passage beds between our Tertiary and Secondary rocks, we have learned through the careful researches of Professor Tate, that *Salenia* and *Belemnites* still exist. Now *Salenia* is a cretaceous form, and I need hardly dwell on the significance of such fossils as *Belemnites*; yet they were associated with truly characteristic fossils belonging to our Australian Tertiary deposits.

But, while so much has been said about the Mesozoic aspect of our Australian fauna, very little has been made of the Miocene

* There are two species of *Pleurotomaria* still living in the West Indies.

aspect of our natural history—yet it is very marked. Attention has been already called by European botanists to the similarity between the plant remains of Miocene age in Europe and the present flora of Australia. The common corals now living in Australia are Miocene fossils of Touraine, Mayence, &c. Our *Conocyathus sulcatus*, E. and H., is very common at Port Jackson. For my own part, I am not very certain about the identity; but the corals are extremely close in any case, and of such marked and peculiar characters, that their occurrence in remote places, and separated by so great an interval of time, is very singular. *Conocyathus sulcatus* is very Turbinolian in its aspect, with four cycles of costæ and only three of septa; the second and third of the latter uniting like many Eocene Turbinoliæ, but with pali and no columella. If we bear in mind the survival of European Miocene forms amongst us, of course it very much weakens the inference that might be drawn from any identity of species between our Tertiaries and beds in Europe whose horizon is well known.

Speaking of the corals generally, we have more affinities with Miocene forms than any other formation; but a few genera are common to both Eocene and Miocene formations. We have no truly Eocene forms such as *Turbinolia*, which are found in the Eocene beds both of Europe and America; neither have we among the many Foraminifera such characteristic fossils as Nummulites; but we have certain American genera which have seldom been found, as far as I am aware, above the Eocene. I shall shortly describe in the Transactions of this Society some few very characteristic Eocene genera of America, and one *Ceratotrochus* (*C. fenestrata*), which is both Miocene and Eocene, as it is both American and European. The commonest of our corals in the Muddy Creek is undoubtedly *Deltocyathus viola*, Woods and Duncan; and of this Professor Duncan says it has a greater resemblance, as far as shape is concerned, to the *Pleurocyathi* of the German Oligocene; but it is a true *Caryophyllia*,* and therefore not in the same sub-division of the Caryophyllian sub-family. Hitherto only one member of the genus has been found in either the Indian, Southern, or Pacific Oceans; there is a new species, *C. Australis*, whose diagnosis will shortly appear in a monograph of our living Australian corals which I am preparing for the Linnean Society of New South Wales. No other species has been found in our fossil deposits, though the individuals are very abundant, which is an anomalous fact, and one not in keeping with the evolution theory. The genus best represented in the number of species, and probably in individuals as well, is *Balanophyllia*. "These," says Professor Duncan, "give a very Falun-

* I have placed this in another genus (*Deltocyathus*) as it departs in many important details from *Caryophyllia*.

nian and Crag facies to the Australian corals as a whole, especially as there are no recent species in the seas around." But I don't think that we are quite without the recent species, as far as I can judge from an examination of many undescribed forms in the Australian museums. I believe there are undescribed species in the Sydney Museum from Port Jackson, and another, if I am not mistaken, in the Macleayan museum, from the East coast further north. Dr. Duncan adds—"Forming a large proportion of the fossil fauna, the *Balanophylliæ* stamps the deposits with a definite character as regards the depth at which they occurred, and this is rendered almost certain by the bathymetrical disposition of the genera *Caryophyllia*, *Flabellum*, *Placotrochus*, *Sphenotrochus*, and *Amphihelia*. The northernmost Faluns (Miocene) contain vast quantities of *Balanophylliæ* (not of species) a *Flabellum*, a *Sphenotrochus*, and there, as in the Australian Tertiaries, every gradation of sea depth, from the abyss to low spring tide mark, is represented by species." (*Quart. Jour. Geol. Soc.*, 1870, *p.* 310.)

With reference to this I must remark that our corals have been collected from beds widely apart, and evidently deposited under different conditions. That where *Caryophylliæ*, *Sphenotrochi*, and *Flabellum* occur we have few or no *Balanophylliæ*. There are few at Muddy Creek, and none at Table Cape in Tasmania. But we have in place of them in the latter place, remarkable species of branching or reef-forming corals; all the others enumerated being solitary, turbinate, and for the most of the genera free. Such forms as *Dendrophyllia*, *Heliastræa*, and *Thamnastræa*, make their appearance in Tasmania, all indicative, in the manner in which they are found, of a deep warmer sea than in Tasmania. Professor Duncan has called in question my opinion that the sea was also a deep one, but I think he misunderstood my meaning. These fossils, no doubt, *grow* in a sea of a few fathoms, but they did not grow where they are found, but are evidently brought from a distance. They are associated with organisms generally found at least in a moderately deep sea, and this is the origin of my opinion. The *Thamnastræa* (*T. sera*, Dunc.) is a very peculiar form of early Mesozoic alliances; in fact, it closely resembles a form from the Lower Oolitic of England (*T. Walcotti*, Duncan). It might, indeed, have been washed out of some older rocks; but there are other specimens, and no other oolitic forms with it. It is, however, always found very much worn and much older in appearance than the accompanying fossils. The *Heliastræa* (*H. Tasmaniensis*, Dunc.) is quite fresh, and unlike the other. It is of a genus of which other Tertiary species exist, but this species has remarkable affinities with an Indian cretaceous fossil (*H. cortica*, Stol.) from the Ootatoor rocks. (See *Prof. Dunc.*, *Q. Jour. Geo. Soc.*, 1876, *p.* 343.) Both these genera had, as before observed, Tertiary representatives, but *Heliastræa* cul-

minated in the Miocene period, while *Thamnastræa* became rare, or died out in the Eocene. I have lately discovered another Mesozoic form in *Smilotrochus*, of which I believe no other Tertiary species has been hitherto found.

Antillia lens (Dunc.) is another anomalous form, with Mesozoic alliances and a genus with no living form, except one in Batavia, and of which a specimen was lately brought down from Darnley Island by the Chevert Expedition, and is now in the Macleayan museum. The genus is well represented in the West Indian Miocene, and in the Sindhian, Travancore, and Arabian Miocene. It is not at all uncommon in the Brighton beds, but there is no other species, and it has no living or fossil representative in these latitudes now.

The general facies of our Australian Tertiary corals is therefore Lower Tertiary, between Eocene and Miocene, with strong Mesozoic alliances. If we separate the different species according to the locality in which they occur, we should find that the Eocene forms predominate in the Tasmanian, Muddy Creek, and Schnapper Point formations, while the Miocene forms are more common in the beds at Spring Creek, sixteen miles south of Geelong, and Portland Bay, Western Victoria.

With regard to the *Echini*, a very interesting paper has recently appeared on the subject from Professor Duncan (*Quarterly Journal Geological Society*, 1877, *p.* 42.) He says that this order, as represented in our rocks, "is very remarkable as a fossil fauna. The presence of such genera as *Temnechinus*, *Echinolampas*, *Pygorhynchus*, and *Eupatagus*, gives a Nummulitic (of Europe and India) facies to the fauna, whilst the Cretaceous aspect is presented by the genera *Catopygus*, *Holaster*, *Micraster*, and a *Rhyncopygus*, with the Ananchytic looking apex." He adds, "that the general facies of the whole is older than is warranted by the geological position." (p. 68.) I cannot well understand what is meant by the "geological position," for that is at present undecided. It must be remembered, on the one hand, that we have in our Australian fauna a genus closely allied to *Temnechinus* (*Temnoplerus toreumaticus*, Klein), and I have found a true *Temnechinus* in very recent Tertiary beds from New Guinea associated with recent fossils, notably *Peronella decagonalis*, Lesson. On the other hand, the difference between our living species and the species of the same genera which are fossil is very marked. There is a very great difference between our living *Lovenia elongata* and the fossil *L. Forbesii*. But I have strong reasons for believing that *L. Forbesii* possesses a true peripetalous fasciole, in which case it would be a *Breynia*, and very closely allied to our living *Breynia Australasiæ*, Gray. *Maretia anomala*,* Duncan, is

* Professor Duncan mentions this genus as West Indian, but this is probably a misprint for East Indian Islands.

a form which is retained in the genus in spite of its having a lateral fasciole, but this does violence to the classification to some extent. There is no such band visible on *M. planulata*, which is not known to naturalists as an Australian species, but which I find is not at all uncommon at Port Jackson and on the east coast. The species is a variable one, the specimens at Port Jackson are smaller, paler in colour, and with much more salient and conspicuous large spines, so that I think we may consider Professor Duncan's species as perhaps a variety. It was found at the mouth of the Sherbrook River in W. Victoria, very far removed from the present habitat. *Monostychia Australis* is another of the forms closely allied to the existing *Arachnoides*, of which two other species are described by Professor Duncan. The genus of *Monostychia* must be abandoned, according to the same author, because it is founded on a mistaken appreciation of the reproductive system and on the position of the periproct. With regard to this I may say that since seeing Professor Laube's monograph I have examined forty or fifty specimens of *Arachnoides placenta* from various localities. I find it a very variable species. The position of the periproct is the most uncertain feature. It is very infra-marginal and marginal. *Psammechinus Woodsii*, Laube, is said to be a form closely allied to our *Echinus magellanicus*, of which Agassiz states that he received two specimens from Australia. It is nearer to a species recently described by me from Darnley Islands *(E. Darnleyensis)*.* There are four species of *Eupatagus* described from our Tertiary beds, all differing but not very considerably from *E. Valenciennesii*—Agas., which is a common living form on the east coast, especially at Port Jackson. *Leiocidaris Australiæ* is a representative of *Dorocidaris papillata*, which is of world-wide distribution; but I am not aware that it has ever been found in Australian seas.

Altogether the facies of our *Echinodermata* is somewhat recent, and in some respects related to past periods of the earth's history. In those respects in which it relates to the past it is at least of early Tertiary affinities, with strong Mesozoic alliances. Its relation to the recent fauna, with only one or at most two exceptions, is to inhabitants of remote localities in Australia and of much warmer seas.

I shall have to deal more generally with the mollusca in treating of their alliances. I hasten in the first place to correct an erroneous impression, conveyed in my last paper read before this Society. I there stated that Australian genera, as the term is understood, were almost entirely absent. I overlooked the fact that I myself have described a new *Cominella* from the Tasmanian beds; and since then Professor Tate has just informed me

* Proc. Linnean Soc., N. S. Wales, Sept., 1877.

that he has found a *Phasianella* and an *Elenchus*. I referred to the *Thalotia*, which I said was doubtful. I think that we must still conclude that our present Australian fauna is not the fauna that we find even generically represented in our Tertiary fossilliferous formations. Naturalists have been accustomed to regard Australia and New Zealand as one province, but this gives rise to a misconception of the molluscan fauna of both localities. Several common New Zealand forms are totally absent from Australia, and New Zealand is singularly deficient in Australian forms. We have only a small *Struthiolaria*, which is rare, and on the east coast only, and we have no *Rotella*, which is a characteristic New Zealand genus. The differences would be too long to enumerate here, but they are at least sufficiently marked to prevent the two places being grouped as one province. As to species, it is quite the exception to meet with instances where they are common to both. We have far more which are common to Australia and the Philippines. But still the differences are great between those two provinces. The facies of our Lower Tertiary molluscan fauna is in a general way Philippine, but it is true only in the sense in which we may say that the facies of the Lower Miocene and Upper Eocene is Philippine. We meet with some existing forms there which represent the fossil fauna of both places, and the genera and general habit of the shells suggest many resemblances. But I repeat that this is only in a general way; for once we try to reduce this to some definite facts, we find that the resemblance is only general and will not bear the test of strict comparison. The truly Australian recent genera may be said to be *Phasianella*, *Elenchus*, *Bankivia*, *Macroschisma*, *Parmophorus*, *(Scutus)*, *Risella*, *Amphibola*, *Trigonia*, *Chamostræa*, *Anatina*, *Myodora*, *Myochama*, *Crassatella*, *Cardita*, *Circe*, *Cyprioardia*, *Venus*, *(Chione)*, *Anapa*, *Mesodesma*, *Panopæa*, *Solenella*, *Spirula*, *Fasciolaria*, *Trophon*, *Pleurotoma*, including *Drillia* and *Daphnella*, *Voluta*, *Mitra*, *Ancillaria*, *Tornatella*, *Trochocochlea*, *Siphonaria*, *Cominella*, *Fusus*, *Liotia*, *Adamsia*, *Crossea*, *Siphonalia*, *Purpura*, *Triton*, and a peculiar trifoliate kind of *Murex*. None of these genera are entirely restricted to Australia, but some are only found in its neighbourhood as far as Japan or the Philippines; while one or two—such as *Solenella*, *Bankivia*, and *Trophon*—reappear at remote places. Thus, Dr. Carpenter reports a solitary *Bankivia varians* among the Mazatlan shells. *Anatina* and *Crassatella* are small characteristic genera. Both are found at the Philippines. *Phasianella* is found at the Philippines as well, and so the list might be continued. But of the above genera we have very few among our fossils. *Crassatella* is one which is common, and so is *Liotia*. *Voluta* and *Mitra* are common and varied; *Cardita* also does not seem scarce, and that common form of *Venus* which is recognized as a subgenus named *Chione* by some authors. A *Venus* very like

V. lammellata exists, but with decidedly specific differences. Our fossil *Pectens* are not at all like our recent forms, but are peculiar—one *P. foulcheri*, nobis, is spinous, *P. yahlensis*, nobis, is finely imbricated, *P. corioensis* is delicately striated, *P. coarctatus** and *P. gambierensis*, nobis, are both coarsely granular; in all of which particulars they differ much from our recent species. *P. yahlensis*, according to Professor M'Coy, so nearly resembles the well-known German Miocene species, *P. Hoffmani*, Goldf., as to be easily mistaken for it; but the valves are both alike in the German fossil, while they are different in the Australian. *Cypræa, (Aricia) gigas* is a very peculiar and large species, differing very much from any form fossil or recent, while *Trivia avellanoides* can scarcely be distinguished from *Trivia avellana* of the British Oligocene, and is very like *T. affinis* of the French Miocene and British Lower Pliocene. The genera best represented in our Lower Tertiary deposits are *Pleurotoma*, *Cerithium*, and *Turritella*. I have carefully compared all our species with a very complete series of the Vienna and French Miocene forms, but find that the resemblances are only remote. There is a far greater similarity between them and those of the Paris basin, but still it is not very close. None of our lower Tertiary *Cerithiadæ* have been described. There is a *Spondylus* (*S. gaderopoides*, M'Coy), which is exceedingly close to *S. bifrons*, Munster, of the Miocene of Westphalia. *Haliotis ovinoides*, M'Coy, and *H. Mooraboolensis*, are both forms with strong resemblances to *H. ovina* and *H. Roei*, Gray, respectively, both of North Australia.

I do not enter at any length into the question of the resemblances of our older Tertiary *Brachiopoda*. Their strong Miocene analogies have been pointed out by many authors, but not the Miocene of France or Austria so much as the Maltese Miocene, where the resemblances, in a few instances, have led to the species being mistaken for one another. The Maltese Tertiary formations have a peculiar facies of their own which merits some notice from all Australian palæontologists. They are described at some length in the *Annals of Nat. Hist.* for July, 1864, by Dr. Leith Adams, and the *Brachiopoda* in the same paper by Mr. Thos. Davidson. He says the Maltese Islands, which extend about 29 miles, all belong to one series, and are to be considered portion of an early Miocene equivalent to the Hempstead beds of England, which was regarded by Sir Chas. Lyell as Upper Eocene. The formations are sedimentary and marine, with a horizontal stratification, and are all conformable. The greatest thickness above the sea level is about 800 feet. Those who wish to study these strata,

* As the name *P. coarctatus* was applied to a fossil figured by me which I thought was identical with a European species, I now propose the name of *P. stenos* for the same shell, as it has not been described, and is not *P. coarctatus*.

which certainly throw some light on our Tertiary beds, will find the following references useful:—"*On the Geology of the Maltese Islands, with Notes on the Fossils by Prof. E. Forbes, Proc. Geol. Soc. Lond., vol.* 4, *p.* 225." "*On Fossil Echinoderms from Malta, &c., by Thos. Wright, M.D.: Ann. Nat. Hist., Feby.* 1855, *p.* 101; also *Fossil Echinoderms of Malta, by Wright: Jour. Geol. Soc. for* 1864, *vol.* XX, *p.* 470." These deposits are very rich in fossils, and the strata are divided into five groups, each of which is distinguished by peculiar organisms. They are so like our Australian deposits that I enumerate them:—1. Coralline limestone; 2. Yellow sand; 3. Clay; 4. Calcareous sandstone; 5. Hard cherty flintstone. The *Echinodermata* are the most abundant and characteristic fossils. Judging from the figures of Wright, there are few that resemble our fossil species except *Echinolampas Deshayesii*, which is in no way distinguishable from my *Echinolampas Gambieriensis*, which I think is the one described by Laube as *E. ovulum*, and considered by him a distinct species from the Maltese form, *Pygorhynchus Vassali*, Wright, and another which is regarded as identical by Professor Duncan. Dr. Wright considered it as resembling *Catopygus fenestratus* from the upper chalk of Belgium, and differing but slightly from *Nucleolites* (*Pygorhynchus*) *subcarinatus* of the Middle Tertiaries of Bünde. Professor Duncan remarks that the genus is essentially tertiary, but Forbes described one which is probably a *Cassidulus*, from the Indian cretaceous. The numerous species have been found in Eocene and Miocene deposits of Malta, America, and Jamaica. *Brissus oblongus*, Forbes (see Wright, *Ann. Nat. Hist.*, vol. 15, 2nd series, p. 184), is not to be distinguished from our existing *Linthia Australis*, Gray. The only difference is the number of pairs of pores, and this depends upon age. There are also a few pairs of pores instead of a single row on the actinal anterior ambulacra. It would be interesting to find that some Eocene or Miocene forms of Europe which are not to be found in our contemporaneous rocks survive in the existing fauna here. There are not wanting facts which would support this view—it certainly is the case with the corals. *Linthia Australis* sometimes attains a very large size, but generally it is found of the dimensions given by Dr. Wright. The Maltese *Spatangus ocellatus*, Defranc, is extremely like our *Lovenia Forbesii*, Woods and Dunc., but they belong to different genera. I question, however, whether the mere absence of a visible fasciole is a sufficient distinction, considering how very easily when there is no depression such a mark disappears. It is very rare to see the internal fasciole on our fossil, but it seems to me that even from Wright's figures (*Journal Geological Society*, vol. 20, pl. 21, figure 1) there are evidences of such a mark. I should infer it from the atrophy of the apical pores of all the petals. I commend this to the attention of palæontologists in England who can refer to the specimens.

To sum up all the evidence which has been gathered on this subject, we may say that our Tertiary formations probably range through all the various Miocene periods which are represented by different deposits on other portions of the globe. We may certainly conclude that the whole of the central parts of South Australia, the north of Tasmania, and the Islands of Bass' Straits, were under the sea during that epoch. There is quite sufficient evidence to show that we have Tertiary rocks of a lower horizon than the Miocene. I conclude this from the small percentage of recent species, the relations of the fossils, and the general facies.

It is also evident that our fossils are with very few exceptions such as we only find at present in much warmer seas. This fact, which all palæontologists are agreed upon, joined to the discovery of certain reef-building kinds in Tasmania, has led to a most interesting discussion recently at the Geological Society of London, when the President, Dr. Duncan, suggested that it might be accounted for by supposing an alteration in the earth's axis. This was further suggested might be accounted for by a shifting of the earth's crust on a fluid and molten mass. It seems to me, however, of very little real service to science to make such speculations. They rest on such slight inferences that they are readily overturned, and really give us no insight into the question. If I might venture to offer an opinion to men so much more qualified than myself to judge, I should say that the theory is too much for the facts. If anything altered the axis of the earth, so as to place, let us say, Tasmania within the tropics, we should expect to find a tropical marine fauna as well. But do we find this? On the contrary, the species are those of a warm sea for the most part; but were we to find such a fauna in a warm sea, we should be equally puzzled to account for the presence of certain species and for the absence of others. Another remarkable peculiarity about our older fossil shells is, that they are thin and fragile, and with the exception of a few species they are anything but substantial. Now, I need hardly remind any one acquainted with the marine molluscan fauna of the tropics, how the first thing that strikes one is the solid and substantial nature of the shells, and for the most part the thickened character of the ornamentation, enamel, &c. Certainly our Lower Tertiary fauna is not a tropical or even a subtropical one. All that we can say is, that certain species which are found still living now inhabit the tropics, while others remain where they are, and generally very many of the genera are now to be found in a warmer climate. It is very remarkable to find specimens of reef-building corals; but we can hardly assert under what conditions they lived, since they are so very different from the reef-builders of the present day. I suppose it is hardly attempted to account for the reef-building corals

which we find in the British coral rag (oolitic), for instance, by climatical conditions alone. It seems to me that we are too imperfectly acquainted with the circumstances which govern the migration of species at present to be able to apply even generally any reasoning to such facts as those before us. Climate alone will not account for them. Indeed, we have nothing very cogent to urge against those who might read the facts in another way, that is by saying that species which now live in warm seas were formerly inhabitants of temperate or even cold waters.

In conclusion, I may remark that throughout the whole of Australian Tertiary palæontology we find a certain peculiar character, which is often distinguished by its almost capricious variation from well-known types of the other hemisphere. I remember hearing a distinguished naturalist remark that he was astonished when he first came to Australia to find so many of the birds "wrong." That is, I suppose, that they seemed by their peculiarities to stray outside the rigid definitions of genera, and sometimes unite the characters of two or more. This certainly must arise from our having formed our systems too artificially from our limited experience. It was natural to suppose that the study of organisms in remote countries would widen our knowledge, and cause us to widen our conception of nature's plan. What we called the Australian "abnormalities" are in reality the shortcomings of our systems of natural history. Thus, we find a *Maretia* with a lateral fasciole, and certain other peculiarities in our *Echini* which would be very difficult to enumerate without entering too much into detail. In the corals the relations of the septa and costæ are most peculiar and exceptional. According to Edwards and Haime, costæ are modified or extra-mural septa. They ought, therefore, to correspond with the septa, and so they do generally. But there are exceptions—such as *Stephanophyllia* and *Microbacia*—where they alternate with them. In *Dasmia*, one of the costæ corresponds to three septa. But in the Australian species everything is exceptional. We have alternating costæ and septa, and in *Ceratotrochus fenestratus*, mihi, we have the triple septa to one of the costa as in *Dasmia*, besides many other differences. We have also *Dendrophyllia epitheca*, that is to say with a thick epitheca, *Flabellum* with basilar radiciform appendages of *Sphenotrochus*. In the *Volutes*, of which mention has been made, we have always a swollen pullus at the apex, and this often forms the only mark of distinction. In *Voluta strophodon*, M'Coy, there is no difference appreciable from *Volutilite spinosus* and *V. depauperatus* of the Upper Eocene of Europe except the apex (See *Prod. Palæontology of Victoria, Dec. IV. p.* 25). I might extend these instances very considerably; but a very slight acquaintance with the fossils themselves will furnish abundant instances.

There can be no doubt that these observations on the fossil fauna might be much amplified, were our knowledge of the marine fauna of Australia more complete. Each day, however, adds to this knowledge, which is very different now from what it was when I first came to the Colony, twenty-three years ago, when such an estimate as I have made would have been impossible. It is to be hoped, however, that what I have thus far noted may be of use, and will give an impetus to the inquiries which are being prosecuted now on every side of Australia.

NOTE.—While these sheets were passing through the press, Prof. Tate informs me that he thinks he has found stratigraphical evidence showing the Muddy Creek beds to be above the Murray cliffs, and the latter as contemporaneous with the Mount Gambier limestones. These questions can hardly be decided without a careful survey. My paper professes to deal with the palæontological evidence only. Prof. Tate's zeal and industry in the matter gives hope of a speedy solution of many of these problems.

DISCUSSION.

The Chairman conveyed the thanks of the Society to the Rev. Mr. Woods for his very valuable paper.

Mr. WOODS said he desired to add that in making these investigations one difficulty he had experienced was that in our colonial museums there were no characteristic recent marine faunas represented. He meant to say that if he wanted, in any museum in Melbourne, Adelaide, Tasmania, or New South Wales, to find recent marine fauna as a means of comparison, he should look in vain for any such collection, and students must be without the instruction such a collection would give. He wished to make this known; and he thought that members of the Society ought to make this matter their first care. If he wanted to obtain in any colonial museum a collection of recent echini, or corals, or shells, he would be unable to find it. This was a matter which museums ought to give their best attention to. Such a collection would be a most useful acquisition.

A Synopsis of the known Species of Australian Tertiary Polyzoa.

By R. Etheridge, junr., F.G.S., of H. M. Geological Survey of Scotland, formerly Assistant Geologist, Geological Survey of Victoria.

[*Communicated by* Rev. W. B. Clarke. *Read before the Royal Society of N.S.W.*, 5 *Sept.*, 1877.]

1. *Introduction.*—I trust the following brief "Synopsis" of the Australian Tertiary Polyzoa may be of use to workers in that department, and may be the means of saving them, to some extent at least, both time and trouble in searching out the bibliography of the subject. With it must always be associated the names of the Rev. J. E. Tenison-Woods, F.G.S., and Prof. Busk, F.R.S. To the geological acumen and perseverance of the former we are indebted for one of the most complete works on the Upper Australian Tertiaries yet published, and it is through his labours as a collector that we owe our knowledge of the organisms in question.

2. *History and Bibliography.*—Tertiary Polyzoa appear to have been first collected in Australia, of which we have any definite record, by Captain Charles Sturt, during his memorable boat-voyage down the river Murray. Several forms were figured in his work, "Two Expeditions into the Interior of Southern Australia,"[1] published in 1833, obtained from the cliffs at the great north-west bend of the Murray. Unfortunately these figures were unaccompanied by descriptions of any kind, and we are left to form an opinion as to their relation with species since described, purely from general resemblance. The reference of his specimens made by Captain Sturt to species at that time known as European (at least I presume so from the names given in his list) will not, I think, stand; in fact this has already been pointed out for some of them by the Rev. J. E. Tenison-Woods.[2]

After Sturt's original discovery of fossils in the tertiary beds of the Murray, the matter appears to have dropped out of sight until systematically taken up by Mr. Woods. His first paper on the subject, so far as known to me, was published in 1859, entitled, "Remarks on a Tertiary Deposit in South Australia."[3] In

[1] London: 2 vols. 8vo., vol. ii. pp. 253–54, pl. 3.
[2] Geological Observations in South Australia, 1862, p. 105.
[3] Trans. Phil. Institute, Victoria, 1859, vol. iii. pp. 84–94.

this communication he referred, after giving a good deal of geological information, to the occurrence of a *Cellepora*-like coral in the Mount Gambier deposit.[1] In the next year (1860) another paper by Mr. Woods was published, having been read, like the preceding one, before the Philosophical Institute of Victoria (now the Royal Society), "On the Tertiary Deposits at Portland Bay, Victoria."[2] The author here notifies the discovery of polyzoa by himself, in beds equivalent to those of Mount Gambier, at the Whaler's Bluff, Portland Bay.

The first really important contribution to the history of Australian Tertiary Polyzoa appeared as an Appendix by Prof. Busk to another paper of the Rev. Mr. Woods', "On some Tertiary Rocks in the Colony of S. Australia," published in the Quarterly Journal of the Geological Society of London.[3] In the paper itself, the country between the Glenelg River on the S.E., the Murray on the N.E., and Spencer's Gulf on the west is described, one of the chief points brought forward being the occurrence of a bed of limestone, a few feet below the surface, almost entirely made up of fragments of Polyzoa. The specimens collected from this bed in the neighbourhood of Mount Gambier were submitted by Mr. Woods to Prof. Busk, who gives in the Appendix a list of the species determined by him, amounting in all to thirty-nine or forty, distributed through fifteen or sixteen genera, four of which were new to science. "Taken as a whole," says Prof. Busk, "these fossil forms exhibit such generic and specific types as to render it probable that the formation in which they are found corresponds in point of relation to the existing state of things with the lower crag of England."[4]

In 1862, the Rev. J. E. Tenison-Woods published his "Geological Observations in S. Australia,"[5] in which he gives an interesting and instructive description of Mt. Gambier, and lists of the fossils from the bed of limestone at that locality. Of the latter there are mentioned of Polyzoa fifteen genera and thirty-seven species, but unfortunately no names beyond the generic ones are given.[6] Two species are figured, *Retepora sp.*, and *Cellepora Gambierensis*, Busk. A table is also given, showing the identity of the species figured by Capt. Sturt from the Murray Cliffs section with those obtained by the author from the Mt. Gambier limestone. Eight species of Polyzoa are mentioned, of which five are common to the two localities.[7] More appears to have been published on this

[1] *Loc. cit.*, p. 91.
[2] Vol. iv. pt. 2, pp. 169–172.
[3] 1860, vol. xvi, pp. 253–261.
[4] *Op. cit.*, p. 260.
[5] London, 1862, 8vo., pp. 18 and 404.
[6] *Loc. cit.*, p. 78.
[7] *Ibid*, p. 105.

subject in 1865 than in any one year before or since, up to the present time. We have, first, two papers by Mr. Woods, one in the Quarterly Journal, "On some Tertiary Deposits in the Colony of Victoria,"[1] and the other in the Transactions of the Royal Society of Victoria, "On some Tertiary Fossils in South Australia."[2] In the first of these a deposit of yellow and brown clays, underlying dolerite lava, around Hamilton, Victoria, is described. It contains Mollusca, Foraminifera, Corals, and Polyzoa. The latter are less common than at Mount Gambier, and appear to be of a more recent facies. In the second of the foregoing communications the author notices the resemblance of the Mount Gambier deposit to the English Lower Crag. He describes seven of Mr. Busk's previously named species, and refers to seven others. Thirteen figures are given.

The same volume of the Victorian Transactions contains a paper by Mr. H. Watts, "On Fossil Polyzoa,"[3] in which an account is given of a deposit containing Polyzoa 30 miles east of Warrnambool, extending along the sea-coast for a distance of from 6 to 7 miles, and is from 30 to 40 feet thick. A portion of this deposit, three or four pounds in weight yielded forty-six species of Polyzoa, but unfortunately no names are given. In 1865 there was also published the report by my friend and former colleague, Mr. C. S. Wilkinson, F.G.S., "On the Cape Otway District," attached to Mr. Selwyn's Geological Survey Report for 1864–65.[4] He mentions the occurrence of *Cellepora Gambierensis*, Busk, in the calcareous portion of the yellow sandy limestone forming the upper part of the Spring Creek section, near Geelong.[5] It is necessary to refer here to one of the results of the Austrian "Novara Expedition," which, although not directly connected with matters purely Australian, yet must be taken into account in all future investigations on Australian Tertiary Polyzoa. It appears that a large number of specimens of the latter were collected by the Expedition from the Tertiary Greensand of Orakei Bay, Auckland, and were described by the late Dr. Stoliczka, in one of the volumes descriptive of the results of the Expedition.[6] He describes two of the Australian Tertiary

[1] 1865, vol. xxi, pp. 389–394.
[2] Vol. vi, pp. 3–6, plate.
[3] pp. 82–84.
[4] Report of the Director of the Geol. Survey of Vict. for the period from June, 1863 to Sept., 1864, with appendices. Victoria, 1864–65, No. 44. Report on Cape Otway District, by C. S. Wilkinson, pp. 21–28. Sketch map and section.
[5] *Loc. cit.*, p. 23.
[6] Paläontologie von Neu Seeland. Beiträge zur Kenntniss der Fossilen Flora und Fauna der Provinzen Auckland und Nelson. Novara Expedition, Geologischer Theil, 1 Band. 1 Abth., No. 4. Fossile Bryozoen aus dem Tertiären Grünsand stein der Orakei Bay, Auckland, pp. 87–158.

species as occurring in the Orakei Bay Greensand, viz., *Cellepora Gambierensis* and *Mellicerita angustiloba*, Busk, and makes many critical remarks on some of the other Australian forms, which will be referred to hereafter.

So far as my acquaintance with the present subject goes, there appears to have again been a lapse of time before any further progress was made in the study of Tertiary Polyzoa in Australia. In 1874, Mr. R. B. Smyth, F.G.S., gave, in his "First Progress Report of the (then) Geological Survey of Victoria," a list of the fossil organic remains of Victoria, drawn up by Professor M'Coy.[1] The only Tertiary Polyzoa mentioned are *Retepora Maccoyi*, R. Etheridge, from the Oligocene beds of Schnapper Point, and *Cellepora Gambierensis*, Busk, from Miocene strata.

In 1874, a short notice of one of the preceding fossils by myself was published in the Transactions of the Royal Society of Victoria,[2] "On the occurrence of a species of *Retepora* (allied to *R. Phœnicea*, Busk), in the Tertiary beds of Schnapper Point, Hobson's Bay." To the species in question I gave the name of *Retepora Maccoyi*, and I also pointed out the occurrence in the same deposit of one of the Orakei Bay forms, *Spiroparina vertebralis*, Stoliczka.

In the "Monthly notices of Papers and Proceedings of the Royal Society of Tasmania," for March, April, and May, 1875,[3] the Rev. Mr. Woods has an excellent paper "On some Tertiary Fossils from Table Cape, Tasmania," in which he describes a large series of the higher mollusca; but only one Polyzoon, the before frequently mentioned *Cellepora Gambierensis*, Busk. Its occurrence in the Table Cape beds is a point of much interest.

In 1875 Mr. R. B. Smyth issued his "Second Progress Report of the Geological Survey of Victoria." A most interesting and important discovery is here recorded, that of fossils in a ferruginous rock overlying an auriferous gravel at the Welcome Rush, near Stawell. In addition to several species of Mollusca, a single Polyzoon is mentioned and figured, *Lepralia Stawellensis*, M'Coy.[4] The deposit is considered by Mr. Smyth to be of the same age as the Flemington series near Melbourne.

In again referring to this discovery in his "Third Progress Report" for 1876, Mr. Smyth places the Stawell ferruginous bed on the horizon of the oldest gold drift (Lower Pliocene).[5]

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[1] Melbourne, 8vo., pp. 35–36.

[2] Vol. xi, pp. 13–14.

[3] pp. 13–26.

[4] pp. 21–22.

[5] pp. 48, 71, and 81. Fossils were first found here by Mr. Bernard Smith in 1872, but it is due to the researches of my friend and former colleague, Mr. Norman Taylor, that we owe the second and much more important discovery at the Welcome Rush. (See his "Report on the Stawell Gold Field," contained in Mr. Smyth's "Progress Report," 1876, pp. 263-64.)

I now pass on to the Synoptical list of the species mentioned or described by the authors whose works I have called attention to. I trust that the references, as abbreviated, will be comprehended by all who may have occasion to refer to them. It is more than probable that when the Australian Tertiary Polyzoa are systematically worked out, certain specific determinations of various authors and their generic references will require careful revision. In the present paper, it has been more my desire to show what is the state of our present knowledge on the subject than to critically pass in review each separate species.

The genera are arranged alphabetically in their respective sections "*Articulata*," or "*Inarticulata*," and the species in a similar manner under them. This has been done for convenience of reference.

In a recently published paper, "On some Tertiary Fossils from Table Cape,"[1] the Rev. J. E. Tenison-Woods has given some interesting details of the Tertiary beds and fossils at that locality. Amongst the latter he mentions *Cellepora Gambierensis*, Busk.

Class—POLYZOA.

Order—GYMNOLEMATA.

Sub-order—CHEILOSTOMATA.

Section Articulata.—Polyzoarium divided into distinct internodes by flexible joints.

Genus CANDA. *Lamaroux*, 1816.[2]

Obs. One well established species of this genus has been determined by Prof. Busk in the Rev. Mr. Woods' gatherings from the Mount Gambier coralline limestone, as given in the appendix to his paper "On some Tertiary Rocks in the Colony of South Australia, &c."

1. CANDA ANGULATA. *Busk.* Quart. Jour. Geol. Soc. 1860, xvi, p. 260; Woods, Trans. R. Soc. Vict., vi, p. 4; pl. 1, f. 2.

Genus ONCHOPORA. *Busk*, 1855.[3]

Obs. Of this genus, established by Prof. Busk in the Quart. Jour. Microscopical Science, again, only one species has as yet been noted from the same horizon and collection as the last. *C. angulata.*

1. ONCHOPORA PUSTULOSA. *Busk.* (MS.), *loc. cit.* p. 260, *Cellaria,?* Stoliczka. Pal. Neu Seeland, p. 149. No description of this species has as yet appeared.

[1] Papers and Proceedings, R. Soc., Tasmania, for 1875 (published 1876), pp. 13–26.

[2] Histoire des Polpiers Coralligènes Flexibles, p. 131.

[3] Quarterly Jour. Microscopical Science, iii, p. 320; according to Stoliczka, this genus possesses the same characters as D'Orbigny's genus *Tubucellaria.* (Pal. N. Seeland, p. 145.)

2. O. VERTEBRALIS. *Stoliczka*, *Speroporina*. Pal. Neu Seeland, 1865, p. 106, pl. 17, f. 6 and 7; R. Etheridge, junr., Trans. R. Society, Vict., 1874, xi, p. 14. Prof. Busk considers this form to be a *Cheilostome*, and not one of the *Cyclostomata* as placed by the late F. Stoliczka, and further to be a species of his genus *Onchopora*. Tertiary greensand of Orakei Bay, New Zealand; and Oligocene beds of Schnapper Point, Hobson's Bay, Vict.

Genus SALICORNARIA. *Cuvier*, 1817.[1]

Obs. Four species of this very elegant generic type have been discovered in the Australian upper tertiary deposits. Two have been determined by Prof. Busk, and two by the Rev. Mr. Woods. They are:—

1. SALICORNARIA GRACILIS. *Busk*. Brit. Museum, Cat. Polyzoa, 1852, pt. 1, p. 17, pl. 63, f. 3, pl. 65, *bis*. f. 2; Woods, Trans. R. Soc. Vict., vi, p. 4. Coralline limestone of Mt. Gambier, S. Australia.

2. SALICORNARIA PARKERI. *Busk*. (MS.) Quart. Jour. Geol. Soc., 1860, xvi, p. 260. An undescribed species—same horizon and locality as last species.

3. S. SINUOSA. *Hassall*. *Farcimia*. Annals Nat. History, 1841, vi, p. 172, pl. 6, f. 1 and 2; *Salicornaria*. Busk, Monograph. Foss. Polyzoa Crag., 1859, p. 23, pl. 21, f. 5; *Glauconome rhombifera*. Sturt, Two Expeditions Interior S. Australia, 1833, ii, p. 254, pl. 3, f. 5, *Salicornaria*. Busk. Quart. Jour. Geol. Soc., 1860, xvi, p. 260; Woods, Geol. Observations, S. Australia, 1862, pl. 1, f. 5.; Trans. R. Soc. Vict., vi, p. 4, pl. 1, f. 1. More than ordinary interest is attached to this species, as it was one of the forms collected by Capt. Sturt in his memorable boat expedition down the Murray, and it figured in his interesting work. The identity of *Glauconome rhombifera*, Sturt (non *Goldfuss*) with *Salicornaria sinuosa* was pointed out by the Rev. J. E. T.-Woods, in the work in which he has so ably illustrated the geology of S. Australia. It is found in the coralline limestone of Mt. Gambier, the Murray River cliffs, the Muddy Creek beds, Hamilton, Vict., *S. tenuirostris*, *Busk*. Brit. Museum Cat. Polyzoa, 1852, pt. 1, p. 17, pl. 63, f. 4.; Woods, Trans. R. Soc. Vict., vi, p. 4. Mt. Gambier, S. A.

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[1] Le Règne Animal, vol. iv, p. 75.

Section INARTICULATA.—Polyzarium continuous throughout.

Genus CABEREA. *Lamx.*, 1816.[1]

Obs. The Mount Gambier coralline limestone has furnished Mr. Woods with one species, and it is, so far as I know, the only one yet determined from Australian beds.

1. CABEREA LATA. *Busk.* Brit. Museum, Cat. Polyzoa, 1852, pl. 1, p. 39, pl. 47; Woods, Quart. Jour. Geol. Soc., 1865, xxi, p. 394; Trans. R. Soc. Vict., vi, p. 5, pl. 1, f. 11.

Genus CELLEPORA. *O. Fabricius* 1780.[2]

Obs. This genus is numerously represented in the Australian tertiary deposits, and is particularly characteristic of the Mount Gambier beds, as both Prof. Busk and Mr. Woods have pointed out. No less than seven species have been detected there, and an eighth doubtfully so. Dr. Stoliczka applied the name *Orbitulipora*[3] to spherical flat-depressed *Cellepora*, such as are figured from the Mount Gambier deposit by the Rev. Mr. Woods.[4] He further considers that one of his Orakei Bay species, *Celleporaria* (=*Cellepora*) *globularis*, may be found amongst the South Australian forms under a different name.

1. CELLEPORA COSTATA. *Busk* (MS.), Quart. Jour. Geol. Soc., 1860, xvi, p. 261—Mt. Gambier.
2. C. ECHINATA. *Sturt.* Two Expeditions Interior S. Australia, 1833, ii, p. 252, pl. 3, f. 4—Another of the forms detected by Capt. Sturt in his expedition. It is at present difficult to say what relation it bears to *C. echinata*, Münster[4]—probably little or none. Murray River Cliffs and Mt. Gambier.
3. C. GAMBIERENSIS. *Busk.* *Eschara celleporacea.* Sturt, Two Expeditions Interior S. Australia, 1833, ii, p. 253, pl. 3, f. 1.

Cellepora Gambierensis. *Busk* (MS.), Quart. Jour. Geol. Soc., 1860, xvi, p. 261; Woods, Geol. Observations S. Australia, 1862, pp. 74, 85, 91; Trans. R. Soc. Vict., vi, p. 4, pl. 1, f. 3, *Celleporaria.* Stoliczka, Paleontol. Neu Seeland, p. 141, pl. 20. f. 7, *Cellepora.* Woods, Monthly Notices R. Soc. Tasmania, March, May, 1875, p. 14. Of all the Australian Tertiary Polyzoa this is perhaps the most interesting form, from the quantity in which it is found, its peculiar characters, large massive form, wide geographical distribution, and

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[1] Histoire Polyp. Coral. Flexible, p. 128.
[2] Fauna Groënlandica, 1780, p. 434.
[3] Pal. Neu Seeland, 1865, pp. 121–122.
[4] Geol. Observations, S. Australia, plate, p. 73.

constant recurrence at certain horizons in the Australian tertiary series. The species was originally found in the Murray Cliff section by Sturt; named by Busk from specimens collected at Mt. Gambier by Woods; then figured by the latter in his S. Australian work; recorded from the Spring Creek section, near Geelong, by Wilkinson[1]; again from a Victorian locality by Mr. R. B. Smyth[2]; described and figured in detail for the first time by Stoliczka from the tertiary beds of Orakei Bay, New Zealand, and, lastly, again discovered in the Table Cape beds, Tasmania, by the Rev. Mr. Woods. *Cellepora Gambierensis* is said by Dr. Stoliczka to be still living on the coast of New Zealand.

4. C. HEMISPHERICA. *Busk.* Quart. Jour. Geol. Soc., 1860, xvi, p. 261; Woods, Geol. Observations, S. Australia, 1862, pl. 1 f. 3; Trans. R. Soc. Vict., vi, p. 4, pl. 1, f. 4. Capt. Sturt figured a form as *Cellepora escharoides* in his two Expeditions (vol. ii, pl. 3, f. 5) which is probably referable to this species, rather than to the *C. escharoides*, Goldfuss[3]. Murray River Cliffs and Mt. Gambier.

5. C. NUMMULARIA. *Busk.* Quart. Jour. Geol. Soc., 1860, xvi, p. 261; Woods, Geol. Observations, S. A., 1862, pl. 1, f. 1; Trans. R. Soc. Vict., vi, p. 4, t. 1, f. 5. Mount Gambier, S. A., and perhaps also at Geelong, Vict.[4]

6. CELLEPORA SPONGIOSA. *Busk.* Quart. Jour. Geol. Soc., 1860, xvi, p. 261; Woods, Geol. Observations, S.A., 1862, pt. 1, f. 2; Trans. R. Soc. Vict., vi, p. 5, pl. 1, f. 7. Mount Gambier, S. A.

7. C. TUBULOSA. *Busk.* Quart. Jour. Geol. Soc., 1860, xvi, p. 261; Woods, Trans. R. Soc. Vict., vi, p. 5, pl. 1, f. 6. Mount Gambier, S. A.

Genus CÆLESCHARA. *Busk.* 1860 (MS.)

Obs. This is a manuscript name used by Prof. Busk in the appendix to the Rev. Mr. Woods' paper "On some Tertiary Rocks in South Australia."

1. CÆLESCHARA AUSTRALIS. *Busk.* (MS.) Quart. Jour. Geol. Soc., 1860, xvi. p. 261. Mount Gambier limestone.

Genus ESCHARA. *Ray (pars)*, 1724.

Obs. As the genus *Cellepora* was exceedingly characteristic of the Mount Gambier beds, so Mr. Woods states is *Eschara* peculiarly typical of the Hamilton series in Victoria, no less

[1] Cape Otway Report, 1865, p. 23.
[2] Progress Report, Geol. Survey Vict., p. 36.
[3] Petrefacta Germaniæ, i, p. 28, t. 12, f. 3.
[4] Woods, Quart. Jour. Geol. Soc., 1865, xxi, p. 394.

than eleven different forms occurring there;[1] and further, those of the Hamilton beds are remarkable for the singular beauty of their cells, the Mt. Gambier species on the other hand being comparatively destitute of ornament.

1. ESCHARA ARCUATA. *Busk.* (MS.) Quart. Jour. Geol. Soc., 1860, xvi, p. 261. Mt. Gambier, S. A.
2. E. BIMARGINATA. *Busk.* (MS.), *loc. cit.* p. 261. Mount Gambier, S. A.
3. E. HASTIGERA. *Busk.* (MS.), *loc. cit.* p. 261. Mount Gambier, S. A.
4. E. INORNATA. *Busk.* (MS.), *loc. cit.* p. 261. Mount Gambier, S. A.
5. E. OCULATA. *Busk.* (MS.), *loc. cit.* p. 261. Mount Gambier, S. A.
6. E. PAPILLATA. *Busk.* (MS.), *loc. cit.* p. 261. Mount Gambier, S. A.
7. E. PIRIFORMIS. *Sturt.* Two Expeditions Interior S. A., 1833, ii. p. 253, pl. 3, f. 2; Woods' Geol. Observations S. Australia, 1862, p. 105. Goldfuss has described a species of *Eschara* under this name,[2] which Capt. Sturt probably took his form to be. Murray Cliffs, S. A.
8. E. SIMPLEX. *Busk.* (MS.) Quart. Journ. Geol. Soc., 1860, xvi, p. 261. Mt. Gambier, S. A.
9. ESCHARA, SP. IND. Woods' Geol. Observations, S. A., 1862; pl. 1, f. 7. Mt. Gambier, S. A.
10. ESCHARA, SP. IND. *Sturt.* Two Expeditions Interior S. A., 1832; ii, p. 253, pl. 3, f. 3. Murray Cliffs, S. A.

To the above must now be added the following *ten* species of *Eschara* described by the Rev. J. E. Tenison-Woods in 1876,[3] viz.:—

E. CAVERNOSA. Mount Gambier.
E. PORRECTA. Mount Gambier.
E. CLARKEI. Muddy Creek.
E. VERRUCOSA. Mount Gambier.
E. RUSTICA. Mount Gambier.
E. ELEVATA. (? monilifera. *Busk.*) Mount Gambier.
E. LIVERSIDGEI. Mount Gambier.
E. OCULATA. Mount Gambier.
E. TATEI.
E. BUSKII. Mount Gambier.

[1] Woods, Quart. Jour. Geol. Soc., 1865, xxi, p. 394.
[2] Pet. Germaniæ, i, p. 24, t. 8, f. 10.
[3] Journal of Roy. Soc. N. S. W., vol. x, 1877, p. 147–149.

Genus Lepralia. *Johnston*[1], 1838.

Obs. This very extensive genus is represented in the Australian tertiaries probably by many species, but so far as I know only four have received names.

1. Lepralia doliiformis. *Busk* (MS.) Quart. Jour. Geol. Soc., 1860, xvi, p. 261. Mt. Gambier coralline limestone.
2. L. Stawellensis. *M'Coy*. Smyth's Progress Report, 1875, No. 2, p. 22, f. 1. This species was discovered by Mr. Norman Taylor, in a ferruginous stratum overlying an auriferous drift at the "Welcome Rush" near Stawell, Vict., and from its geological position and associated fossils is of much importance and interest. The ferruginous deposit is placed by Mr. R. B. Smyth on the horizon of the Melbourne Flemington beds (= L. Pliocene.)
3. L. Subcarinata. *Busk* (MS.) Quart. Jour. Geol. Soc., 1860, xvi, p. 261. Mt. Gambier coralline limestone.
4. L. Submarginata. *Busk* (MS.), *loc. cit.* p. 261. Mount Gambier coralline limestone.

Genus Lunulites. *Lamarck*[2], 1876.

Obs. Undetermined species of this genus occur both in the Mount Gambier limestone and Muddy Creek (Hamilton) beds, according to the Rev. Mr. Woods.

I. Lunulites. sp. ind. (2) Woods. Quart. Jour. Geol. Soc., 1865, xxi, p. 394.

Genus Melicerita. *Milne Edwards*, 1836.[3]

Obs. The only hitherto recorded species of *Melicerita* is of interest from its geographical distribution. It is also of interest from the limited number of species occurring in the European Tertiaries, and again as one of the commonest forms at Mt. Gambier.

Melicerita angustiloba. *Busk*. Quart. Jour. Geol. Soc., 1860, xvi, p. 261; Woods, Geol. Observations, S. Australia, 1862, pl. 1, f. 4; *id.* Trans. R. Soc. Vict., 1865, vi, p. 5, pl. 1, f. 8; Stoliczka, Paleontol. Neu Seeland, p. 155, pl. 20, f. 15—18. Mt. Gambier Coralline limestone, S. A.; Muddy Creek beds, Hamilton, Vict.; Tertiary greensand of Orakei Bay, New Zealand.

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[1] History Brit. Zoophytes, p. 277.
[2] Hist. Anim. sans Vertèbres, vol. ii.
[3] Annales des Sciences Naturelles, vi, p. 347.

Genus MEMBRANIPORA. *De Blainville*, 1830.[1]

Obs. Of this genus, always one of the most difficult to deal with in a fossil state, not only from the great amount of variation a species is liable to go through, but also from the worn condition in which specimens are usually found, four species have been recorded from Australian tertiary rocks.

1. MEMBRANIPORA APPRESSA. *Busk* (MS.) Quart. Jour. Geol. Soc., 1860, xvi, p. 261. Mt. Gambier limestone.
2. M. FIDENS. *Hagenow, Busk.* Monograph. Foss. Polyzoa Crag, 1859, p. 34, pl. 2, f. 4; Quart. Jour. Geol. Soc., 1860, xvi, p. 260; Woods, *ibid*, 1865, xxi, p. 394. Mt. Gambier limestone, S. A.
3. M. CYCLOPS. *Busk.* British Museum, Cat. Polyzoa, 1854, pt. 2, p. 61, pl. 65, f. 3. Quart. Jour. Geol. Soc., 1860, xvi, p. 261; Woods, *ibid*, 1865, xxi, p. 391. Mt. Gambier limestone, S. A.; Muddy Creek beds, Vict.
4. M. STENOSTOMA. *Busk.* British Museum, Cat. Polyzoa, 1854, pt. 2, p. 60, pl. 100, f. 1; Quart. Jour. Geol. Soc., 1860, xvi, p. 260; Woods, *ibid*, 1865, xxi, p. 394; Mt. Gambier limestone, S. A.

Genus PSILESCHARA. *Busk.* 1860 (MS.)

Obs. Another manuscript name used by Prof. Busk in the paper previously referred to.

1. PSILESCHARA PUSTULOSA. *Busk.* (MS.) Quart. Jour. Geol. Soc., 1860, xvi, p. 261. Mt. Gambier limestone.
2. P. SUBSULCATA. *Busk.* (MS.), *loc. cit.* p. 261. Mt. Gambier limestone.

Genus RETEPORA. *Imperato*, 1672.

Obs. The Australian species of this genus require strict revision. It is very difficult to say what two out of the four recorded species may turn out to be when strictly investigated, they having been identified originally by Captain Sturt with European species, which so far as can be judged from his figures they certainly do not appear to be.

1. RETEPORA DISTICHA. *Sturt.* Two Expeditions, Int. S. Australia, 1833, ii. p. 254, pl. 3, f. 6; Woods, Geol. Observations, S. Australia, 1862, p. 105. This is not *R. desticha*, Goldfuss (Petrefacta Germaniæ, i, p. 29, pl. 19, f. 15), but is more probably *Hornera Gambierensis*, Busk, or perhaps an *Idmonea*.
2. RETEPORA MACCOYI. *R. Etheridge, jun.* Trans. R. Soc. Vict., 1874, xi, p. 14. Oligocene beds of Schnapper Point, Port Phillip Bay, Vict.

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[1] Dictionnaire des Sciences Naturelles, tome Zx, p. 411.

3. R. MONILIFERA. *M'Gillivray.*[1] Trans. R. Soc. Vict., 1860, iv, pt. 2, p. 168, pl. 3; Woods, Quart. Jour. Geol. Soc., 1865, xxi, p. 394. Mt. Gambier limestone, S.A.
4. R. VIBICATA. *Sturt.* Two Expeditions Interior S. Australia, 1833, ii, p. 254, pl. 3, f. 7. *Retepora*, sp., Woods, Geol. Observations S. Australia, 1862, p. 74, fig.—. *Ret. silicata, id. ibid,* p. 105. This is not *Retepora vibicata*, Goldfuss (Petrefacta Germaniæ, i. p. 103, pl. 36, f. 18), as Capt. Sturt appears to have thought. Both the latter and the Rev. Mr. Woods figure the same species; that of the last named is considered by Dr. Stoliczka[2] to be possibly *R. Beaniana*, King, Murray R. Cliffs and Mt. Gambier limestone, S.A.

Genus SCUTULARIA. *Busk* (MS.), 1860.

Obs. This, at present only a manuscript name, Mr. Busk informs me (by letter) is intended for the reception of certain forms not unlike *Lunulites* but with different zœcia. It was probably a free form, and may perhaps be placed in Mr. Busk's family *Selenaridæ*.

1. SCUTULARIA PRIMA. *Busk* (MS.) Quart. Jour. Geol. Soc., 1860, xvi, p. 261. Coralline limestone, Mt. Gambier, S. A.

Sub-order CYCLOSTOMATA.

Section ARTICULATA.

Genus CRISIA. *Lamouroux*, 1812.[3]

Obs. Only one species has as yet been noted from the Australian tertiaries.

1. CRISIA EBURNEA. *Linnæus.* Johnston, British Zoophytes, 1847, i, p. 283, pl. 50, f. 3 & 4; Woods, Trans. R. Soc. Vict., 1865, vi, p. 5, pl. 1, f. 12; Quart. Jour. Geol. Soc., 1865, xxi, p. 394, Busk; Brit. Museum Cat. Polyzoa, 1875, pt. 3, p. 4, pl. 2, f. 1 & 2, pl. 5, f. 1 & 2, 5–10. Mount Gambier limestone, S. A.

Section INARTICULATA.

Genus HORNERA. *Lamouroux*, 1821.[4]

Obs. This genus is divisible into two well marked sections, according as the frond is ramose or fenestrate. For the latter group a distinct name *Retihornera* has been proposed by Herr

[1] Notes on the Cheilostomatous Polyzoa of Victoria, and other parts of Australia. *Trans. Phil. Institute Vict.*, vol. iv, 1860, pt. 2, pp. 159–168, pls. 2 & 3.
[2] Pal. Neu Seeland, 1865, p. 125.
[3] Bulletin des Sciences de la Société Philomatique, &c., vol. iii, p. 183.
[4] Exposition Méthodique des Genres de l'Ordre des Polypiers, 1821, p. 41.

Kirchenpaur. The best known of the Australian tertiary species of this genus, *H. Gambierensis*, Busk, is one of the ramose forms.

1. Hornera Gambierensis. *Busk*. Quart. Jour. Geol. Soc., 1860, xvi, p. 261; Woods, Trans. R. Soc. Vict., 1865, vi, p. 5, pl. 1, f. 10. The form figured by Capt. Sturt as *Retepora disticha* (*see ante*), is probably identical with that given by Woods as *H. Gambierensis*, although I think it has more the appearance of an *Idmonea* than *Hornera*. Mt. Gambier limestone, S. A.
2. H. rugulosa. *Busk*. Quart. Jour. Geol. Soc., 1860, xvi, p. 261; Woods, Trans. R. Soc. Vict., 1865, vi, p. 5, pl. 1, f. 9? Mt. Gambier limestone, S. A.

Genus Idmonea. *Lamouroux*, 1821.[1]

Obs. Two species have been obtained from the Mount Gambier limestone.

1. Idmonea ligulata.—*Busk*. (MS.) Quart. Jour. Geol. Soc., 1860; xvi, p. 261, Stoliczka, Pal. Neu Seeland, 1865, p. 114.
2. I. milneana.—*D'Orbigny*. Zoologie, Voyage dans l' Amérique Mérid., p. 20, t. 9, f. 17–21. Busk, Quart. Jour. Geol. Soc., 1860, xvi, p. 261. Woods, *ibid*, 1865. xxi, p. 394; Stoliczka, Pal. Neu Seeland, 1865, p. 114. This is a living species on the coast of Tierra del Fuego, Patagonia, and other places.

Genus Pustulopora. *De Blainville*, 1830.[2]

Genus Entalophora. *Lamouroux*, 1821.

Obs. Prof. Busk observes that perhaps the more correct generic term for polyzoa of this description is the second of the foregoing names, which has been adopted by Dr. Stoliczka in his description of the Orakei Bay fossils.

1. Pustulopora distans. *Busk*. Quar. Jour. Geol. Soc., 1860; xvi, p. 261. Mount Gambier limestone. Dr. Stoliczka remarks that this species may possibly be identical with his *Entalophora Hasstiana*.[3]
2. P. ungulata. *Woods*. Mount Gambier.[4]
3. P. corrugata. *Woods*. Mount Gambier.[4]

Genus Tubulipora. *Hagen*.

1. T. Gambierensis. Mount Gambier.[4]

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[1] Exposition Méthodique des Genres de l'Ordre des Polypiers, &c., Suppl. p. 80.
[2] Dictionnaire des Sciences Naturelles, 1830, p. 382.
[3] Pal. Neu Seeland, p. 103.
[4] Journal Roy. Soc. New South Wales, 1876, vol. x, p. 150.

In the following table I give a list of the species mentioned in the foregoing Synopsis which are at present living, arranged in alphabetical order.

Genus and Species.	Localities.
1. *Caberea lata.* Busk	Australia, New Zealand. Busk.
2. *Crisia eburnea.* Linn...............	European Seas.
3. *Idmonea Melneina.* D'Orb.	Tierra del Fuego, Patagonia. Busk.
4. *Membranipora cyclops.* Busk ...	New Zealand. Busk.
5. „ *stenostoma.* Busk	Tasmania; East Falkland Islands. Busk.
6. *Retepora monilifera.* M'Gilv......	King's Island, Bass's Strait; Queenscliff, Vict.
7. „ *Beaniana.* King...... (? *R. vibicata.* Sturt)	North Britain. Busk.
8. *Salicornaria gracilis.* Busk......	Cumberland Islands, Cape Capricorn. Busk.
9. „ *sinuosa.* Hassal	British Seas.

NOTE.—In addition to these, the characteristic *Cellepora Gambierensis*, Busk, is said by Dr. Stoliczka (Pal. N. Seeland, 1865, p.—) to be probably still living on the coasts of S. Australia and N. Zealand. The Rev. Mr. Woods states that *Membranipora bidens*, Hagenow, is also a living species. Quart. Jour. Geol. Soc., 1865, xxi, p. 394.

2. In conclusion I give a statement showing the species common to the various localities.

a. Species common to the Mt. Gambier limestone and Murray River cliff beds.

1. *Cellepora echinata.* Sturt. (? *C. hemispheria.* Busk).
2. „ *escharoides.* Sturt. (? *C. hemispheria.* Busk).
3. „ *Gambierensis.* Busk.
4. *Retepora disticha.* Sturt. (? *Hornera Gambierensis.* Busk.)
5. *Retepora vibicata.* Sturt. (? *R. Beaniana.* King.)
6. *Salicornaria sinuosa.* Hassal.

b. Species common to the Mt. Gambier limestone and Hamilton beds.

1. *Cellepora nummularia.* Busk ?
2. *Melliocrita angustiloba.* Busk.
3. *Membranipora cyclops.* Busk.
4. *Salicornaria sinuosa.* Hassal.

c. Species common to the Mt. Gambier Limestone and Spring Creek beds.

1. *Cellepora Gambierensis*. Busk.
2. „ *nummularia*. Busk ?

d. Species common to the Mt. Gambier Limestone, and the Greensand of Orakei Bay, Auckland, N. Z.

1. *Cellepora Gambierensis*. Busk.
2. *Idmonca Melneina*. D'Orb.
3. *Pustulopora distans*. Busk ? (? *Entalphora Hoastiana*, Stol.)

e. Species common to the Schnapper Point beds, Victoria (*Oligocene*), and the greensand of Orakei Bay, Auckland.

1. *Onchopora* (*Spiroporina*) *vertebralis*. Stol.

Ctenacanthus, a Spine of Hybodus.

By W. J. Barkas, M.R.C.S.E.; L.R.C.P.L.

[*Read before the Royal Society of N.S.W.*, 3 *October*, 1877.]

In the Geological Magazine for April, 1874, there appeared a paper written by me entitled "Hybodus, a Coal Measure Fish." In it I attempted to prove that the fish Hybodus existed earlier in the world's history than the Jurassic Age as was stated by Professor Agassiz and others, and I supported my opinion by comparing certain teeth that had been discovered in the true Coal Measures, and which up to that time had been designated Cladodus, with engravings of teeth of Hybodus and Cladodus from the works of Agassiz, Newbery and Werthen. This direct comparison of the external characters of the teeth of the above-named fishes showed, as I think, most conclusively that a fish having teeth similar to those of the Jurassic Hybodus existed during the Coal Measure period. In the third and fourth chapters of my papers on the "Microscopical Structure of Fossil Teeth from the Northumberland True Coal Measures," which appeared in the "Monthly Review of Dental Surgery" for 1874, I gave a full account of the microscopical structure of the teeth of Hybodus from the Wealden and of the so-called Cladodus from the Carboniferous system, and exhibited engravings of the structure of Cladodus (?) from the latter formation; I also pointed out in these papers that the histological characters of the teeth of Hybodus from the Wealden differed very slightly indeed from the structure of the teeth which I consider to pertain to Hybodus (Cladodus ?) belonging to the Coal Measures. My investigations, therefore, led me to the conclusion that most of the teeth found in the true Coal Measures which had been named Cladodus did not belong to that genus at all, but to the genus Hybodus; the remainder, comparatively few in number, were undoubtedly true Cladodi; also that these Coal Measure Hybodi and Cladodi teeth possessed similar structures, just as the Hybodi teeth from the Wealden resembled the Cladodi teeth from the Mountain Limestone. When I published my researches I was not aware that any other palæontologist had discovered teeth of Hybodus in the true Coal Measures, but since then I have ascertained that Giebel, in his "Fauna der Vorwelt," describes in

a very brief manner the external characters of two varieties. This I take to be a corroboration of the opinion I arrived at independently.

These three papers treated only of the fact of the teeth of Hybodus being found in the upper Coal Measures, but incidentally I mentioned that the teeth of Hybodus and Cladodus were discovered comparatively frequently associated with the spines of Ctenacanthus, and that from that and other circumstances I was of opinion that the reputed spine of Ctenacanthus was undoubtedly a spine of Hybodus.* It is with the intention of giving further proof in confirmation of the view I then casually published that I have undertaken to write this paper, and I shall (following the plan I adopted in my "Hybodus, a Coal Measure Fish") place before you the descriptions of the spines of Ctenacanthus and Hybodus as given by other palæontologists, viz., Agassiz, Münster, &c., and descriptions of the so-called spines of Ctenacanthus in the possession of Mr. T. P. Barkas, F.G.S.

After having thus referred to the external characters of these spines, I shall draw attention to their microscopical structure and point out what similarity there may be between the minute characters of an undoubted spine of Hybodus and those of a reputed spine of Ctenacanthus. In order that there might not be the slightest doubt as to the veritableness of the spine of Hybodus from which the sections for microscopical examination were to be made, I wrote to two of our greatest palæontologists, the Earl of Enniskillen and Sir Philip de Grey Egerton, for portions of an undoubted spine; they very graciously supplied me with the required specimens, and it is from them that I made my sections. With regard to the sections of the spine of Ctenacanthus being undoubted, I may state that the remains of the spines that I destroyed to make them are in Mr. T. P. Barkas' possession, and also that the sections were cut from five or six different spines, and from different portions of those spines.

The spines of the genus Hybodus, according to the late Prof. Agassiz, present the following external characteristics:—"Les rayons de ce genre, surtout ceux des espèces du Lias, se font remarquer par leur grandeur considérable. Ils ont une forme et des caractères extérieurs très-caractéristiques. Ils sont généralement *un peu arqués,*† *plus gros et plus larges vers leur base qu'à leur extrémité, et se terminent en une pointe plus ou moins*

*Although I consider Ctenacanthus spines to pertain to Hybodus, I shall keep the original names throughout this paper, with the understanding that Ctenacanthus means Hybodus found in the Coal Measures, and that Hybodus refers to the spines obtained from the Lias, Wealden, &c.

† The italics in these quotations are my own.

amincie. La partie de leur extrémité inférieure qui était cachée dans les chairs, est assez considérable, *elle égale le plus souvent le tiers de la longueur totale;* elle est finement striée longitudinalement et ouverte en côté postérieur en forme de sillon très-évasé qui se resserre pour former une cavité intérieure assez spacieuse et qui s'étend jusque vers l'extrémité du rayon. La partie des rayons qui soutenait le bord antérieur des nageoires est *plus ou moins arrondie, légèrement comprimée latéralement*, coupée moins ou plus *carrément au bord postérieur* et arrondie au bord antérieur; toute sa surface, du moins *les côtés et le bord antérieur, sont ornés de fortes arêtes longitudinales arrondies*, plus ou moins parallèles au bord antérieur du rayon et qui alternent avec des sillons assez profonds et à peu-près de mêmes dimensions que les arêtes qui séparent. Vers le bord antérieur ces arêtes et ces sillons sont généralement plus gros, plus profonds, plus larges et plus distans que vers le bord antérieur (*sic*), *le long duquel ils se confondent fréquemment, ainsi que* vers la pointe. Le long du bord postérieur, qui est plus ou moins plat et finement strié en long, il y a *deux rangées* plus ou moins distantes de grosses dents acérées, et arquées vers la base du rayon; vers son extrémité ces deux rangées de dents se *rapprochent de plus en plus*, et *finissent souvent* par se confondre entièrement sur la ligne médiane." In describing *Hybodus apicalis* he says:—"*le bord antérieur est aussi plus arqué que le bord postérieur, qui est presque droit, sauf la pointe qui se courbe assez subitement.*" Then again, with regard to *H. curtus*—"Le sillon postérieur de la racine est très-évasé, et la cavité intérieure assez considérable vers la base; mais elle se rétrécit rapidement vers l'extremité du rayon." In *H. leptodus*—"Les dents des bords postérieurs sont grêles et assez distantes, c'est-à-dire, plus distantes les unes des autres que les sillons longitudinaux:" When describing the longitudinal ridges of *H. reticulatus* he remarks—"Ils sont au contraire souvent sinueux, et s'anastomosent de temps en temps." In *H. formosus* the grooves on the anterior surfaces of the spine are "finement granulés." According to Agassiz then, the above are the principal external characters of different spines of Hybodus. He mentions seventeen other varieties, at least he makes them species, though I think he has in this case fallen into the bad habit of hair-splitting, for many of the spines he describes are mere fragments, others are exceedingly similar and some are evidently crushed specimens; in fact to distinguish these twenty-two varieties from his drawings requires a remarkable amount of imagination.

Count Münster, in his "Beiträge zur Petre-facten-kunde," gives the following short account of *H. hexagonis*—"Der rucken und die Seiten dieses Ichthyodoruliten sind stark gefurcht; Rippen und Furchen gleich breit; die eckige Banchseite ist glatt; der Durchschnitt zeigt eine länglich sechsseitige Form. Nach

einem zweiten Bruchstücke wird Ruckenstachel doppelt so gross." An evidently incomplete description of a portion close to the apex of the spine.

We have now learnt the appearances presented by the spines of this genus, from two of the greatest authorities; and the portions of the spines of Hybodus that I possess, and from which I made sections, correspond to the above descriptions.

I will now refer to the external characters of the spines of Ctenacanthus in my possession and quote the descriptions of others; we shall then be in a better position to institute comparisons between Ctenacanthus and Hybodus. Let us take Agassiz first. He says:—"Les Ctenacanthus ont d'immense rayons très-comprimés, à base large * * La partie de ces rayons cachée dans les chairs paraît avoir été considérable. Au bord postérieur se voient quelques petites épines. La surface est ornée de striés longitudinales, plus rapprochées que celles des Hybodes, pectinées, c'est-à-dire, crénelées transversalement et saillantes en forme de dents qui alternent d'une série à l'autre, mais qui semblent continuer à cause de leur obliquité." In describing *C. major* he observes—"Le rayon est élégamment arqué en forme de faux * * Au bord postérieur du rayon, et vers sa pointe seulement, on remarque quelques petites épines, ou plutôt quelques rides plus saillantes en forme de peigne sur le sillon marginal * * Sa coupe transversale est ovale, arrondie du côté de la face postérieur du rayon et tranchante à son bord antérieur. La ligne de démarcation entre la partie sillonée du rayon * * et sa base lisse * * est très-oblique."

The descriptions of Ctenacanthus given by McCoy in his "British Palæozoic Fossils," and by Messrs. Newberry and Werthen in the "Geological Survey of Illinois, U. S.," are similar to the above, with the exception that the spines they mention are smaller and finer. M'Coy, however, remarks further that "the fin-defences of this genus are confined to the Devonian and Carboniferous rocks, where they seem to represent the genus Hybodus of the Mesozoic period."

In my own collection and in the cabinets of others I have had the opportunity of examining upwards of two dozen spines of Ctenacanthus, and in their external characters hardly any two agree precisely. They vary in length and breadth exceedingly, some being very large, but these are the rarest, and I have seen none so large as the *C. major* figured by Agassiz in his "Poissons Fossiles," tome 3, tab. 4, fig. 2; others are comparatively small and thin like *Hybodus dorsalis* exhibited in tab. 10, fig. 1, of the above work. They are *generally a little arched*, but are in some cases perfectly straight; in others the anterior border is curved while the posterior is straight, the apex being bent in some cases, and in others not. They are large at the base and gradually and

often rapidly become narrower till they terminate in a point more or less sharp. The portion of the spine buried in the flesh is considerable enough and generally equal to the third of the total length, but it is very rare to obtain this portion of the spine entire; it is finely and longitudinally striated; the division between this portion of the spine and the ridge or exposed part is marked by a very distinct line of demarcation, which is sometimes very oblique and often curved. The posterior surface of the base of the spine is open, a very deep furrow extending deeply into the body; as this furrow proceeds upwards it becomes closed in posteriorly and forms an oval cavity, this oval character is in many cases lost, for numbers of the larger spines, having necessarily large cavities, have been crushed in by the superincumbent pressure; the cavity extends nearly to the apical extremity. The exposed portion of the spine is rounded anteriorly, more or less compressed laterally, and its posterior surface is slightly concave, the concavity being very shallow near the apex, making the surface there nearly flat. The anterior surface and sides are marked by longitudinal ridges, which are separated from each other by grooves of nearly the same dimensions as the ridges; the grooves and ridges run parallel with the anterior border, but as they approach the apex they become fewer in number by anastomoses, and in some cases when close to the extremity they disappear altogether, leaving a small surface which is minutely striated; in the large specimens the ridges proceed quite to the point. The sulci are often smooth, but occasionally they are finely granular or even longitudinally striated. The ridges, according to all palæontologists, are generally supposed to be tuberculated or crenelated, but this is evidently a mistake, for among the specimens I have observed, I have examined six in which the ridges were perfectly smooth and rounded as in Hybodus; in other cases they varied from being strongly tuberculated on the lateral and anterior surfaces of the spine to being slightly denticulated on the posterior ridges of the lateral surfaces only, the non-tuberculated ridges being smooth and rounded. The posterior surface I have said is slightly concave, and on each side are arranged from one to two rows of obtuse denticles; the intervening space is finely striated; the obtuse denticles of *H. marginalis*, shown in tab. 10, figs. 18-20 in Agassiz' 3rd volume, closely resemble them.

A careful comparison of the above descriptions of Ctenacanthus and Hybodus will show that the so-called spines of Ctenacanthus differ from the spines of Hybodus in very few particulars, in fact in two only, first, that the posterior surface of the former has sometimes four rows of teeth, which are situated on the sides of that surface instead of near the centre as is generally observed in Hybodus, but Agassiz figures in tab. 10, fig. 3, of his third

tome a spine, *H. leptodus*, in which the teeth are situated like those in Ctenacanthus, however Hybodus has never four rows of denticles that I am aware of. Second, that the longitudinal ridges on the exposed portion are often tuberculated. Of course the tuberculated variety of Ctenacanthus may be considered quite a distinct species from those with smooth ridges, but I cannot accept this opinion, for the spines present every variation between the two extremes, and both varieties are found associated with the teeth of Hybodus and Cladodus and also with undoubted dermal tubercles, which were consequently designated tubercles of Ctenacanthus; finally these two varieties have exactly the same microscopical structure. For the purposes of comparison with the spines of Hybodus, I have of course chosen the most typical specimens of Ctenacanthus. No. I* is the upper portion of a spine of Ctenacanthus; on its lower part it is to be observed that there are two rows of denticles on the posterior surface, and that as they proceed upwards one row disappears. Suppose I had taken a portion of this spine near the apex and placed it side by side with the small pieces exhibited by Münster in his "Beiträge zur Petrefacten-kunde," Tafel xvi, figs. 16 and 17, one would have had some difficulty in distinguishing which was Ctenacanthus and which Hybodus. No. II is a portion near the base, it closely resembles the same portion of the spine of *Hybodus formosus* which is figured by Agassiz in his "Poissons Fossiles"; these spines are so alike at their base that no dissimilarity is noticeable in the marking on the part that was buried in the flesh, in the line of demarcation between that portion and the spine proper, or in the smoothness of the ridges on the exposed portion. A transverse section through No. I shows the shape of the internal cavity and the slight concavity of the posterior surface; with the exception of being larger, there is little difference between this section and the section of *H. pleiodus* exhibited in "Poissons Fossiles," vol. 3, tab. 10, fig. 17. The transverse sections of Ctenacanthus given by Agassiz must not be compared with similar sections of Hybodus, because the former are very far from correct, in fact, if his drawings were true to nature they would cause Ctenacanthus to resemble Hybodus still more strongly than I have shown it to do. I have stated that all the specimens I have examined, and that were in perfect condition, were slightly concave on the posterior surface of the ridged portion of the spine, but that sometimes the surface was flat near to the apex. Now, Agassiz, in his descriptions and figures of *C. tenuistriatus* (Poiss. Foss., vol. 3, tab. 3, figs. 10, 11) makes that surface evenly convex at the lower portion, and as it proceeds towards the apex it bulges out more and more

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* Referring to specimens I have had the opportunity of examining.

at its centre. Then again, in *C. major* (tab. 4, fig. 3) the posterior surface "est ovale et arrondie." These descriptions and figures are manifestly incorrect; it may be that the specimens he examined were either crushed spines or else much buried in the matrix; if they were not, then the spines were not appurtenances of the fish he named Ctenacanthus. All the specimens I have examined have similar appearances to No. II at their base, except when the specimen has been crushed, which is almost invariably the case near the lower extremity, where there is not any cavity, but a broad, deep excavation perfectly open at the posterior part.

The microscopical structure of these spines is very little known, the only author that I am acquainted with who attempts to describe it is Agassiz; in his "Poissons Fossiles," tome 3, he gives two engravings (tab. A., figs. 8 and 9) of the structure of *Hybodus reticulatus*, they are, however, poor representations; and on page 215 he refers briefly to the general structure, but it would be impossible from that description, even with the aid of his illustrations, to recognise a section of Hybodus under the microscope. He remarks—"Ce genre ne se distingue du précédent (Asteracanthus) que par le plus grand nombre de couches concentriques qui entourent là cavité médiane et dans lesquelles on distingue également des tubes calcifères dendritiques, mais en petit nombre. Les lisières obscures qui se trouvent entre la dentine claire dont les canaux secondaires sont entourés sont trés-larges et présentent un aspect finement pointillé. Pour toute la reste, la structure est entièrement semblable à celle des Asteracanthus." The latter spine he states is similar in structure to the spine of Gyracanthus; thus Hybodus, according to Agassiz, has some points of resemblance to Gyracanthus, though what the points are he does not say. His description of the structure of Gyracanthus is unfortunately wrong, but it has I know many points of resemblance to Ctenacanthus and therefore to Hybodus. Agassiz does not refer to the structure of Ctenacanthus. Having therefore no authority upon whom I can depend for a correct account of the minute structure of Hybodus and Ctenacanthus, I shall rely solely upon sections that I have had made in my presence. In order to prevent a great amount of repetition I will state at once that the structures of these two spines are very similar, for under the microscope it is well nigh impossible to say which is which. In preparing the sections great care is required, for if too thick nothing can be seen but the openings of the larger canals and dark tissue between the orifices, and a section of Hybodus cut thus imperfectly I confess does somewhat resemble the drawings of Agassiz; if too thin, then the calcigerous tubules, more especially the finer ones, are broken or ground away. The spine of Ctenacanthus is

permeated by numerous vascular canals, which are open at the extremity of the base where they received their vascular supply; they pass up the spine parallel with its vertical axis and with each other. In the base the course of the canals is very straight, and they appear to maintain an uniform size, their average diameter being $\frac{1}{120}$th of an inch; they branch seldom, but when ramuli are given off they arise nearly at right angles to the parent trunk; the tissue between equals about two-thirds of the diameters of the canals, it is homogeneous and is not arranged round the canals in concentric laminæ; from all the canals arise calcigerous tubules which branch and anastomose very freely with each other, the ultimate branches terminating in a layer of minute calcigerous cells which divides one vascular system from another, or they pass beyond this boundary and inosculate with the terminal branches of the neighbouring system. The diameters of these tubules average $\frac{1}{3000}$th of an inch at their origin and the finer branches average $\frac{1}{13000}$ of an inch. There are no concentric layers of dense vascular tissue surrounding the central cavity near the root, but as we proceed upwards this concentric arrangement becomes observable.

In the body of the spine the canals become slightly altered in character, those near the circumference being much smaller in diameter from the deposition of tissue within them in concentric layers, and those near the centre have also decreased in size to about the 200th of an inch but they are not surrounded by lamellæ. The circumferential portion of the body has now, therefore, a superabundance of tissue over canals, but near the centre they are about equal. From all the canals calcigerous tubes arise, but those near the centre give them off very sparingly, while the vessels near the periphery do so exceedingly abundantly; the tubuli branch very freely and the ramifications anastomose frequently with each other, so much so that where the tubules are numerous, as near the external surface, they fill the tissue between the canals with a fine network. Surrounding each canal and its system of tubules is a distinct boundary composed of calcigerous cells. The tubules from the central canals present a somewhat dendritic appearance. The central cavity is surrounded by layers of tissue denser than the above two varieties of dentine; it is, however, not arranged concentrically but irregularly, and in some parts is pierced by very large canals from which arise long but fine dendritic tubules. As we approach the apex the medullary cavity becomes smaller and smaller, and all the canals are surrounded by laminæ and therefore smaller in diameter.

Such are the characters presented by sections of the spine of Ctenacanthus, and such are the characters observed when similar sections of Hybodus are examined, even the sizes of the tubules

and their branches agreeing. It is extremely difficult to prepare a vertical section of a spine of Hybodus in order to see the tubular arrangement satisfactorily, on account of the hardness of the fossilized spine and of the consequent brittleness when the section is becoming transparent under the grinding process.

We have now compared the spine of Ctenacanthus with that of Hybodus both externally and internally, and to me the proof is most conclusive as to their identity, but to some the mere similarity of form, markings and structure may not be considered as sufficient evidence to settle this matter. I will therefore for their benefit bring forward further geological proof. It is now an accepted fact that the spines of Hybodus are always found in the same formations as the teeth of Hybodus, at least we have the statement of the great palæontologist Agassiz that such is the case; "car non-seulement je connais les rayons et les dents des Hybodes et j'ai la certitude qu'ils appartiennent au même genre, mais encore j'ai pu m'assurer que partout où l'on trouve des rayons de ce type, il existe aussi des dents analogues et *vice versâ*." Now, in my paper, "Hybodus, a Coal Measure Fish," I showed that the teeth of Hybodus were found in the Coal Measures, and in the "Monthly Review of Dental Surgery" for February, 1874, I proved that these teeth of Hybodus from the Coal Measures possessed a similar structure to those obtained from the Wealden. We have therefore shown that teeth are found in the Carboniferous system resembling in every respect the teeth of Hybodus from the Wealden, &c., and that the so-called spines of Ctenacanthus cannot be distinguished from the spines of Hybodus from the Lias, Wealden, &c., either by their external form or by their minute structure. Now the spines of Ctenacanthus are principally found in the Carboniferous formations where the teeth of Hybodus and Cladodus are discovered; we have only, therefore, to bring forward any facts which will tend to show a connection between the teeth and the spines; this is very easily done, for it is acknowledged by all Coal Measure palæontologists that they are frequently obtained associated on the same slab of shale. The best specimen I have seen illustrating this association is from the cabinet of Mr. Ward, of Longton, Staffordshire; it is an undoubted specimen of Ctenacanthus with non-tuberculated ridges, and in close contact with it are thirteen teeth of Hybodus and two of Cladodus, and the whole piece of shale is covered with the so-called Ctenacanthus tubercles. Messrs. Hancock and Atthey, in a paper which they published in the "Transactions of the Northumberland and Durham Natural History Society," stated their belief that the teeth, tubercles and spine, belonged to one fish, and Mr. Thompson of Glasgow has also given the same opinion, although none of them had seen such a specimen as that in the possession of Mr. Ward.

Another proof, though not so direct, is that when the teeth and spines are found separately they are almost invariably associated with the tubercles. Whether similar tubercles have been discovered accompanying Hybodus spines or teeth in the Wealden or Lias I do not know, but even if they have never been found so associated in these formations my view would not receive any confutation, for in order that these light tubercles should be deposited in close proximity to such heavy objects as spines and teeth the water would have to be in perfect quiescence, and then again the character of the fish itself might have undergone change in this respect during the mighty ages which passed away between the Carboniferous and the Jurassic periods.

Both the spines and teeth of Hybodus from the Coal Measures have been found buried in or associated with masses of shagreen and disintegrated cartilage.

Eichwald, a noted palæontologist, after an examination of some spines found in the Carboniferous Limestone of Russia, came to the conclusion that they belonged to Hybodus and named them accordingly *H. panderi*. He also asserts, in his "Lethæa Rossica," that *H. polyprion* of Agassiz has been discovered in the same formation.

To sum up: all the deductions and descriptions drawn out by Agassiz and others with regard to Hybodus from the more recent formations can be applied with equal truth to the spines of Hybodus (Ctenacanthus) and the teeth of Hybodus (Cladodus) from the Coal Measures; the only statement requiring correction is the following from the "Poissons Fossiles":—"Les Hybodes s'étendent depuis le Grès-bigarré inclusivement jusqu'à la Craie, c'est-à-dire jusqu'aux derniers dépôts jurassiques et weldiens; ils existent même dans la Craie." This will require the substitution of "vieux grès-rouge" for "grès-bigarré," for although this paper is directed principally to the Coal Measure remains, undisputed spines of Hybodus (Ctenacanthus) are found in the Carboniferous Limestone and in the Old Red Sandstone. In these latter formations teeth of Cladodus are also discovered, but not those of Hybodus, so far as I am aware. This, however, is of no importance, because it is probable that the fish Cladodus possessed spines exactly similar to Hybodus, if Cladodus be not a true Hybodus, for the genus was founded on teeth alone. The teeth of Cladodus differ from those of Hybodus only in the facts that the secondary denticles of the former *increase* in size as they proceed from the centre denticle, and that they are *always equal* in number on each side of the central cone; while in Hybodus they *decrease* in size and may be *equal or unequal* on each side. Now, I have examined specimens of Hybodus having all the secondary denticles *large* as in Cladodus, but in which they were all the *same height* as the centre denticle and *equal* in

number on each side of it. I have also seen other teeth with the secondary denticles *equal* in number, but *decreasing* in size on each side. We have therefore teeth alike in every respect, with the exception that in some the secondary denticles decrease in size as they proceed from the centre, in others they increase, and in others again in which they remain equal in height. Taking these facts into account, and knowing that the teeth of Cladodus are similar in structure to those of Hybodus,* that they are often found associated with spines, teeth, or dermal tubercles, or it may be with all at once, as in Mr. Ward's specimen, the simplest conclusion we can come to is that Cladodus is only a variety of Hybodus, but I think that the evidence proves that the teeth called Cladodus really pertain to Hybodus, but are situated probably in a different part of the mouth.

We must therefore abolish the genus Ctenacanthus, and I also think the genus Cladodus. With regard to the teeth of Cladodus, I am pleased to find that other Coal Measure palæontologists agree with my opinion that they are only varieties of Hybodus, and therefore that that genus should be abolished. If this be so, then both the teeth and spines of Hybodus extend as low down in the earth's crust as the Old Red Sandstone, rendering the fish Hybodus another of those examples that further research has proved to have existed during a protracted period, and that tends to break down the artificial barrier between Palæozoic and Mesozoic times.

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* See my paper with engravings proving this in the February and March numbers of the "Monthly Review of Dental Surgery" for 1874.

On a System of Notation adapted to explaining to Students certain Electrical Operations.

By the Hon. Professor Smith, M.D., M.L.C., C.M.G., &c., University of Sydney.

[*Read before the Royal Society of N.S.W.*, 3 *October*, 1877.]

For a number of years I have been in the habit of using in my lectures on electricity a simple kind of notation in applying the double-fluid hypothesis to the explanation of Volta's electrophorus, the electrical machine in charging a Leyden jar, and analogous operations. This notation has enabled me to present such operations to students in a more clear and definite form than by any explanations I have found in books. Of course it may be objected that, as the fluid hypothesis is not only not proved, but is in the view of many highly improbable, any ingenuity exerted in applying it to observed facts must be entirely thrown away. But the same objection may be urged, with greater or less force, to any other hypothesis; and if in teaching we are not to make use of any hypothesis until it has been elevated to the dignity of a proved theory, we must repress the imaginative faculty altogether, and adhere strictly to a demonstration of the bare facts, which would I think be dull work for both teacher and taught. Provisionally then we use the fluid hypothesis because it adapts itself readily to all the ordinary phenomena, and affords a simple means of classifying or connecting them together. De la Rive says of it:—"Although subject to strong objections, it is, in the present state of the science, a very convenient and tolerably exact manner of representing to ourselves this agent that we term electricity."

Even those who prefer Faraday's hypothesis of polarization of particles find it difficult, if not impossible, to avoid the use of language that implies the existence of electric fluids. It appears to be thought by some that this molecular hypothesis is inconsistent with, and ought to exclude the fluid hypothesis; but Faraday himself was careful to point out that there is really no incompatibility. In his *Experimental Researches* (No. 514), he says:—"I have endeavoured to establish, what all the facts seem to prove, that when electrical phenomena, as those of induction, conduction, insulation and discharge occur, they depend on and are produced by the action of *contiguous* particles of matter, * * * and I have further assumed that these particles are polarized; that each exhibits the two forces, or the force in two

directions; and that they act at a distance only by acting on the *contiguous* and intermediate particles." In another place (No. 1667) he says:—"The theory of induction set forth * * * * does not assume anything new as to the nature of the electric force or forces, but only as to their distribution. The effects may depend upon the association of one electric fluid with the particles of matter, as in the theory of Franklin, Epinus, Cavendish, and Mossotti; or they may depend upon the association of two electric fluids, as in the theory of Dufay and Poisson; or they may not depend upon anything which can properly be called the electric fluid, but on vibrations or other affections of the matter in which they appear. The theory, though it professes to perform the important office of stating *how* the powers are arranged, does not, as far as I can yet perceive, supply a single experiment which can be considered as a distinguishing test of the truth of any one of these various views." With the humility that was a striking characteristic of Faraday, he said, at a meeting of the British Association at Swansea:—"There was a time when I thought I knew something about the matter; but the longer I live, and the more carefully I study the subject, the more convinced I am of my total ignorance of the nature of electricity."

In making use of hypothetical explanations I am always careful to impress upon my students their provisional nature, and the risk we run of confiding too much in them, and of attributing to them a higher value than our knowledge warrants. On this point Tyndall remarks:—"In our conceptions and reasonings regarding the forces of nature we perpetually make use of symbols which, when they possess a high representative value, we dignify with the name of theories. Thus, prompted by certain analogies, we ascribe electrical phenomena to the action of a peculiar fluid, sometimes flowing, sometimes at rest. Such conceptions have their advantages and their disadvantages; they afford peaceful lodging to the intellect for a time, but they also circumscribe it; and by and by, when the mind has grown too large for its lodging, it often finds difficulty in breaking down the walls of what has become its prison instead of its home."

The fluid hypothesis is sometimes applied in a manner that may to beginners convey erroneous impressions; as, for example, in Tyndall's Notes on Electricity, in explanation of Volta's electrophorus—"If the surface of a cake of resin be electrified, a plate of metal laid upon it will have its neutral fluid decomposed, its positive fluid being attracted and its negative repelled. On touching the metal plate its free (repelled) electricity flows to the earth; and now if the plate be raised by an insulating handle it will appear charged with positive electricity." Now when this positive electricity is given off to a conductor, would it not be

natural to suppose that the plate is entirely deprived of electric fluid? To the same effect is the explanation in Ganot's Physics, translated by Atkinson—"The negative electricity of the cake," he says, "acts by induction on the natural fluid of the cover and decomposes it, attracting the positive fluid to the under surface, and repelling the negative fluid to the upper. If the upper surface be now touched with the finger, the negative electricity passes off, and the cover remains charged with positive electricity, held, however, by the negative electricity of the cake. If now the cover be raised by its insulating handle the charge diffuses itself over the surface, and if a conductor be brought near it a smart spark passes." I do not see how a beginner could very well avoid the inference that the cover is thus entirely deprived of its electric fluid.

Then as to the action of the electrical machine, Tyndall says—"When the glass plate is turned by a handle it passes between the silk rubbers and is positively electrified. The electrified glass then acts by induction upon the prime conductor, attracting the negative electricity and repelling its positive. The conductor is furnished with points from which the negative electricity streams out against the excited glass. Thus the prime conductor is charged, not by directly communicating to it positive electricity, but by robbing it of its negative, the positive remaining behind." And Ganot—"The rubbers communicate with the ground by means of a chain, and consequently as fast as the negative electricity is generated it passes off. The positive electricity of the glass acts then by induction on the conductor, attracting the negative fluid, combining with it to regenerate the natural fluid; the conductors thus lose their negative electricity and remain charged with positive fluid. The plate accordingly gives up nothing to the conductors; in fact, it only abstracts from them their negative fluid." In other books usually in the hands of students the statements are equally liable to misconstruction.

In explaining electrical excitation by the two-fluid theory, I consider it necessary to show that the total quantity of electric fluid belonging to a body is never altered, but its quality may be changed by the substitution of a portion of the one fluid for an equal portion of the other. The neutral or unelectrified condition may be assumed as consisting of the two fluids combined in equal proportions. Whenever this equal balance is in any way disturbed—that is to say, when the electric fluid of a body is all of one kind, or is more than half of one kind, the total quantity proper to the body never varying—then we have electrical excitation or charge. Take, for example, a glass tube and a silk rubber—each with its own proper measure of neutral electric fluid; when they are rubbed together the compound fluid on both bodies gets completely or partially decomposed; the whole or part of the

negative or resinous electricity belonging to the glass passes over to the rubber, and an equal measure of positive or vitreous passes to the glass. Each body continues to have the same quantity of electric fluid attached to it as at first, but the quality of the fluid is changed—each body has now an excess of one fluid, and a corresponding deficiency of the other—and therefore each body is electrically excited or charged, the one positively and the other negatively.

Take now the case of the electrophorus. When the metal cover is put down on the excited cake of resin, the compound fluid of the cover is decomposed by induction, its positive portion being attracted towards the cake and its negative repelled. If the cover be touched by a conductor, a part of the repelled negative is conveyed away and an equal measure of positive takes its place, leaving the total measure unchanged; but there is now an excess of positive, and when the cover is removed from the inductive action of the cake and touched with a conductor, it gives off its excess of positive and receives an equal amount of negative, thus restoring the neutral condition of the cover. Let us see how these changes may be simply represented.

Let V be a measure of vitreous or positive electricity, and R an equal measure of resinous or negative; $V + R$ will then represent the neutral fluid. If we take the fluid on the surface of the resinous cake to be $V + R$ we may suppose it to be entirely decomposed by friction, and it will then become 2 R. Represent the fluid of the cover thus: $\frac{V + R}{V + R.}$ The cover being put down on the cake, the whole fluid will be decomposed by induction and we shall have $\frac{2\ R}{2\ V.}$ Touch the cover with the finger. The 2 R of the cover attracts 2 V from the finger; they combine, and the neutral fluid thus formed is instantly distributed on the contiguous surfaces, $V + R$ going to the cover and the same to the finger. The cover will then show $\frac{V + R}{2\ V}$, V being in excess and R deficient. Remove the cover by its insulating handle and touch it—V is given off, and R received in its place, leaving the cover as at first $\frac{V + R}{V + R.}$

In Dr. Golding Bird's "Elements of Natural Philosophy" a modification of Volta's electrophorus is thus described:—"A thin pane of glass is coated on one side with tinfoil to within about two inches of the edge. Placing it with the coated side on the table, excite the other surface by friction with a piece of silk covered with amalgam; then carefully lifting the glass by one corner, place it on a badly conducting surface, as a smooth table

or the cover of a book, with the uncoated side downwards. Touch the tinfoil with the finger, then carefully elevate the plate by one corner and a vivid spark will fly from the coating to any conducting body near it; replace the plate, touch it, again elevate it, and a second spark will be produced." This simple apparatus is very instructive—more instructive indeed than its designer indicates—and deserves more attention than it appears to have got. It affords an excellent illustration of induction, and of the manner in which the one fluid binds or holds the other prisoner as it were. At the same time it is rather puzzling to students, and the above notation helps to make it plain. The following experiments may be made with this electrophorus: First, lay the coated surface on a book with paste-board cover, and excite the face of the glass plate by friction; of course it becomes charged with positive electricity. Lift up the plate and bring the coated back in contact with a charged electroscope. It gives off positive electricity. Excite the face again, turn over the plate on the book, lift up book and plate together, and again touch the electroscope with the coated back. It is now found charged with negative electricity. (This experiment is not mentioned by Golding Bird.) Remove the plate from the book, and again touch the electroscope with the back; it now gives a positive charge. The great difficulty with students is to understand how the coated back gives a positive spark when away from the book, and a negative when the face of the plate is kept in contact with the book. Let us apply our notation to the successive phases.

At the outset the fluid on each side of the glass plate may be represented as V + R. After friction the face may be supposed to have 2 V. This acts by induction through the glass and tends to repel the V of the back into the book and attract R from the book. The result would be 2 R on the back, if the book were a good conductor; but the book is an imperfect conductor. (To render it so, it should be well warmed at the beginning of the experiment.) The consequence is that only a portion (say half) of the V is driven away, and its place taken by $\frac{1}{2}$ R. We then have on the back $\frac{1}{2}$ (V + R) + R. On lifting the plate away from the book, the 2 V on the face tends to repel the remaining $\frac{1}{2}$ V from the back, which is thus able to charge an electroscope positively. But, on turning the plate over on its face on the book, the 2 V on the face acts by induction on the book in preference to acting through the glass; and, being then bound or masked by 2 R on the book, it no longer has any coercing influence on the electricity of the back. But that electricity has $\frac{1}{2}$ R in excess of the normal quantity, and, if brought into contact with an electroscope, a negative charge will therefore be communicated; at the same time $\frac{1}{2}$ V is received in exchange, and the back of the plate resumes the condition represented by V + R. Finally, on lifting

the plate away from the book, the 2 V of the face acts again by induction through the glass and repels V from the back, which is thus capable of giving a positive spark. As a matter of fact, this last positive charge is much stronger than that obtained when the plate after friction is raised and the back brought to an electroscope; and much stronger also than the negative charge got from the back when the plate and book are raised together. A glance at the notation shows clearly the reason of this.

Turn now to the function of the machine in charging a Leyden jar. In applying our notation we have to consider four separate parts or links in the chain of action: First, the machine consisting of glass and rubber; second, the positive prime conductor; third, the inside of the jar; and fourth, the outside of same, which for the sake of simplicity we suppose connected with the insulated rubber. On each of these parts we may represent the neutral electric fluid as R + V, and we then have—

		Leyden jar.	
Machine.	Pos. P. Cond.	Inside.	Outside.
R + V	R + V	R + V	R + V

On turning the machine the electric fluid is decomposed by friction, all the V collects upon the glass, and all the R upon the rubber. The V on the glass now acts by induction on the neutral fluid of the positive prime conductor, attracting R and repelling V; this latter acts in the same manner on the fluid inside the jar, and the repelled V inside acts through the glass and decomposes the neutral fluid outside. This first step may be represented by simply obliterating the plus signs in the above notation. But at three points, namely, between glass of machine and P.P.C., between P.P.C. and inside of jar, and between outside of jar and rubber, the electricities are separated either by a narrow space of air, or by conducting matter, and the decomposition is instantly followed by recomposition, as shown by sparks; while at the fourth point the insulating glass of the jar prevents recomposition. This state of affairs may be represented as follows:—

	Machine.	Air.	P.P.C.	Air.	Inside.	Glass	Outside.	
+	R V	+	R V	+	R V	|	R V	+ to rubber.

The neutral fluid formed at these three points must be instantly redistributed on the neighbouring surfaces, one half going one way the other half the other way. We then have—

Machine.	P.P.C.
$\frac{1}{2}$ (R + V) + $\frac{1}{2}$ (R + V);	$\frac{1}{2}$ (R + V) + $\frac{1}{2}$ (R + V);

Inside.	Outside.
$\frac{1}{2}$ (R + V) + V	R + $\frac{1}{2}$ (R + V)

Every part has thus exactly the same measure of electric fluid as when we began. On the machine and P.P.C. the fluid is neutral; but on each side of the jar there is an excess of the

one fluid with a corresponding deficiency of the other, and the jar is represented as half charged. Continuing to turn the machine, another cycle of decomposition, recomposition and redistribution is gone through, but now with only half the original amount of fluid. The decomposition and recomposition may be represented together in one line :—

$$+\tfrac{1}{2}R;\ \overbrace{\tfrac{1}{2}(R+V);}^{\text{Machine.}}\ \overbrace{\tfrac{1}{2}V+\tfrac{1}{2}R;}^{\text{Air.}}\ \overbrace{\tfrac{1}{2}(R+V);}^{\text{P.P.C.}}\ \overbrace{\tfrac{1}{2}V+\tfrac{1}{2}R;}^{\text{Air.}}$$

$$\overbrace{\tfrac{1}{2}V+V}^{\text{Inside.}}\quad \overset{\text{Glass.}}{|}\quad \overbrace{R+\tfrac{1}{2}R;}^{\text{Outside.}}\ \tfrac{1}{2}V\ +\text{ to rubber.}$$

and the simultaneous redistribution thus :—

$$\overbrace{\tfrac{1}{4}(R+V)+\tfrac{1}{2}(R+V)+\tfrac{1}{4}(R+V);}^{\text{Machine.}}\ \overbrace{\tfrac{1}{4}(R+V)+\tfrac{1}{2}(R+V)+\tfrac{1}{4}(R+V);}^{\text{P.P.C.}}$$

$$\overbrace{\tfrac{1}{4}(R+V)+\tfrac{1}{2}V+V}^{\text{Inside.}}\ \Big|\ \overbrace{R+\tfrac{1}{2}R+\tfrac{1}{4}(R+V)}^{\text{Outside.}}$$

We still have the original quantity of neutral fluid on the machine and P.P.C.; but on each side of the jar although the quantity is unaltered the quality is more changed, the V accumulating inside and the R outside. It must be needless to represent the action in detail further. The next cycle of operations would give us inside the jar $\frac{1}{8}(R+V)+\frac{1}{4}V+\frac{1}{2}V+V$, and outside $R+\frac{1}{2}R+\frac{1}{4}R+\frac{1}{8}(R+V)$. The series evidently tends to 2 V inside, and 2 R outside, but can never absolutely reach that result.

With this mode of representing the charging of a Leyden jar (hypothetical and artificial as it may be considered) we perceive simple reasons for two well-known facts. First, that judging by the frequency and brilliancy of the sparks the action of the machine while charging gets rapidly weaker. It is because there is less and less neutral fluid to decompose on the jar. And second, we never in practice reach a point where we can say that a jar is fully charged. No doubt a jar will generally discharge itself before saturation is reached; but irrespective of that it would appear that a perfect and complete charge is unattainable. There will always be a residuum of negative electricity inside and of positive outside.

The discharge of a Leyden jar may be represented by the same notation, but the case is too simple to require exemplification. The two fluids being equal in amount on the two sides rush together and form neutral fluid, which is instantly redistributed in equal parts to the two surfaces, leaving the whole covered with the original amount of neutral fluid.

Notes on the Meteorology and Natural History of a Guano Island.

By W. A. Dixon, F.C.S.

[*Read before the Royal Society of N.S.W., 3 October, 1877.*]

Having, during a residence on Malden Island extending over two and a half years, from October, 1866, to March, 1869, made a number of observations on various subjects, I have thought that it might interest some of the members of this Society if I placed them on record. As I have only a superficial knowledge of some of the sciences within whose domain many of the observations lie, it may be that some of them are not new; but as few men have an opportunity of passing a similar period in such a place, it seems probable that some may be, which forms my excuse for venturing to lay them before you.

Malden Island, discovered by Admiral Byron in 1825, is situated in lat. 4° 2′ S. and long. 154° 58′ W., and at that time was uninhabited, though there were signs of previous occupation. The native name of the island, according to the traditions of the inhabitants of Maniki or Humphrey's Island, was "Tera Kupatea," derived from "Tera," the sun, and "Kupatea," the only tree growing on the island, signifying that this formed the only sun-shade. They named several of the chiefs who had lived there, and asserted that the people had been washed off the island. Appearances did not warrant this assertion, however, though it seemed as if the sea had at one time made a breach over one spot, and such an occurrence may have induced the inhabitants to abandon a place possessing few attractions.

In form the island is triangular, and according to a rough survey it covers an area of 19,700 acres, of which about 9,000 is occupied by a lagoon situated considerably east of the centre. On the surface the island is of purely coral formation, the only siliceous mineral found being water-borne pieces of pumice, which in many places were sufficiently numerous, and it is surrounded by a fringing reef, extending pretty uniformly 200 feet from the beach where the depth of water suddenly increases to three or four fathoms, and thence slopes rapidly off into deep water, the rate of descent being about one in two. Immediately inside the reef the bank of the island rises, formed of broken coral and madrepores thrown up by the waves. This bank differs in construction on the different sides of the island, the north and south sides

being alike, and east and west unlike, but all about 400 yards wide. On the north and south sides the outer portion of the bank is formed of successive ridges of madrepores and corals in large pieces forming a strip about 100 yards wide. The ridges, nine in number, are tolerably uniform in height, as are also the hollows between them in depth. The outer ridge presents a somewhat steep face towards the sea, and they all follow the coast-line with great regularity. I had an opportunity of seeing one of these ridges formed during a great tidal disturbance in December, 1868, before which the lower part of the beach was so sloping that one could walk along it without much inconvenience, but the large rollers at that time coming over the reef piled up the whole of this beach with much more material from the fissures in the reef, forming a ridge as high as the others, the sea-face being left almost perpendicular. The height of the north and south banks varied from about 9 feet at the east to 20 at the west end of the island. The bank at the east end also presented a somewhat steep face towards the sea, but it was composed of much smaller pieces, which were seldom larger than about 4 cubic inches. On the top the ridges were less marked, resembling a number of somewhat highly cambered roads running parallel to one another, and the surface was composed of small shingle mixed with sand.

At the west end the beach was composed of a wide strip of coarse coral sand, and the ridges were entirely wanting, the edge of the beach being marked by a line of bushes where the height above mean water level was 21 feet, the highest on the island. Immediately inside the ridges of black broken coral, and separated therefrom by a sharply defined line, the bank was formed of shingle, covered in most places with sand or guano, or both, with occasional scattered slabs of coral rock, and it sloped gradually down to the general level of the interior, except at the east end where the slope ended at the lagoon. This interior slope was covered with vegetation, and on it were several clumps of trees.

The interior of the island was composed of masses of coral rock *in situ*, between which were patches of guano of varying richness, and was about 3 feet above water level, showing that the island had been upheaved to that extent. Near the south side a fissure extended for some distance running east and west, partly open and partly filled in by matter deposited subsequently to its formation. The water in the open part, and in a series of small lagoons forming its continuation rose and fell with the tide, and was inhabited by a small reddish fish about an inch in length, but did not contain any living corals, the only other living creature being a minute thin-shelled mollusc.

The lagoon is similar in shape to the island, and has no open communication with the sea, but is supplied with water through

fissures in the coral rock. The immense evaporation from the surface of the lagoon in continued dry weather causes a constant influx of water, which is only influenced in rapidity by the state of the tide, almost ceasing at low-water, and flowing outwards only at low-water near spring-tides as far as I could observe. During heavy tropical rains, to which the island is at times subjected, the rain-water soaking from the higher surrounding lands washes out the lagoon as it were, and reduces the amount of salts in solution more or less below the standard of sea-water, dissolving at the same time the deposits of salt which have been formed around the shallow margin. The specific gravity of the water in the open sea I found was 1·026, and on different occasions I found that of the lagoon water to be 1·090 and 1·120, representing an evaporation of from two-thirds to three-fourths of the water, whilst on large shallow patches at the west end, where the water was only three or four inches deep, salt crystallized often to a depth of two or three inches.

This alternate evaporation and removal of the more soluble salts has caused large deposits of sulphate of calcium with more or less carbonate to be formed, especially at the west end, towards which the wind is generally blowing, and which is furthest from the fissures through which the water enters. There it covers large tracts only two or three inches above water level, the surface being bound together by a mat of vegetable matter apparently the same or similar to the peculiar marine Thallogen described by M. Aimé Girard as covering the bottom of the salt gardens of Portugal*. This forms a tremulous crust which may be walked upon, whilst underneath, the deposit is a white mud which may be readily probed to a depth of several feet. The wind occasionally removes portions of this crust and carries it with adhering deposit farther west, so that it forms a long slope, which as it rises above the water level is being gradually encroached upon by a thick-leaved plant having the appearance of a mesembrianthemum. This, collecting the dust blown from the drier portions below, forms a ridge about 18 inches high in which the mutton birds burrow holes, altering its appearance by charging it with organic matter and phosphates.

The climate of the island, although lying near the equator, and sometimes having the north-east and sometimes the south-east trades, is generally characterized by extreme dryness. I arrived on the island on the 13th of October, 1866, and on the 5th November there was a heavy rain-fall at night, which I was told was the heaviest for twelve months, although one man said that four years before there was always plenty of rain. From the quantity collected in a bucket standing outside, this rain-fall

* Compt. Rend., LXXI, 1195.

was about 0·5 inch. I then made a rain-gauge, which was placed in the ground in an exposed situation 21 feet above sea-level, but there was no rain-fall to record from that date until the 1st September, 1867, or ten months. The rain-fall then gradually increased until in the begining of 1869 we had a continuance of heavy rains. The following record shows the quantities that fell:—

1866, Nov.	5.	0·50	
1867, Sept.	1	0·036	
	2	0·094	
	4	0·018	
	6	0·012	
	11	0·027	
	12	0·076	
Oct.	13	0·015	
	20	0·201	
	25	0·009	
Nov.	25	0·634	
Dec.	9	0·032	
	10	0·162	
Year	....	1·316	No. of wet days, 12.
1868, Jan.	7	0·408	
	18	0·003	
	26	0·141	
	28	0·126	
Feb.	17	0·002	
March	29	0·106	
April	18	0·016	
	22	0·176	
May	2	0·101	
	12	0·136	
	13	0·234	
	26	0·061	
	28	0·040	
June	7	0·104	
	9	0·008	
	13	0·003	
July	10	0·051	
	11	0·051	
	12	0·050	
	13	0·578	
	15	0·002	
	16	0·068	
	23	2·881	
	27	0·003	
	28	0·102	
	29	0·034	
Aug.	14	0·068	
	18	0·068	
	19	0·663	
	21	0·034	
	26	0·034	

1868, Sept.	3	0·003	
	10	0·102	
Oct.	4	1·681	Temp. of rain 78° F., of air 77° F., wind due S. 6 a.m.
	11	0·998	Temp. rain 77°; air, same; wind, E., 6 a.m.
	18	0·201	
	25	0·007	
Nov.	2	0·031	
	3	0·130	
	4	0·152	
	10	0·002	
	17	0·440	
	24	0·018	Cloudy all day, sun seldom seen; shade 3 p.m. 93° F.; 6 p.m. 81° F.
Dec.	1	1·724	Began to rain 11 a.m., Nov. 30; barometer 29·850.
	11	0·018	Wind east, strong; temperature of rain 80°, of air 84°; rained 19 hours.
	12	0·093	
	13	0·229	
	14	0·752	Dead calm.
	15	0·061	„
	16	0·527	„
	18	0·046	„
	31	0·013	„ Sea very heavy.
For year......		13·580	Number of rainy days, 52.
1869, Jan.	13	0·527	
	16	1·004	Strong west wind; temp. rain 78°; air 82°; barometer 29·85.
	17, 18	1·550	Strong west wind; temp. rain 78°; air 82°; barometer lowest reaching 28·825, got up towards evening to 29·875.
	19	0·682	Very strong west wind; temp. rain 78° F.; air 82° F.
	20	0·558	„ „
	21	1·038	„ „
	22	0·694	„ „
	23	0·217	„ „
	25	0·740	„ „
	26	0·775	Wind east „
	27	0·372	„
	28	0·626	4·571 in 8½ hours. „
	29	3·943	
Feb.	2	0·074	
	13	0·496	
	19	0·223	
	20	0·403	
	21	0·589	
	22	0·682	
	23	0·099	
	24	0·031	
	25	2·232	
March	5	0·031	
	7	0·688	

1869, March	9	0·015	
	19	1·360	Thunder and lightning; barometer usual.
	22	0·446	
	23	0·229	
		20·234	28 days rain in 3 months.

It was noticeable that during the day-time it frequently rained in heavy showers on all sides, without any falling on the island. Heavy rain clouds came up from the east, which as they came over the island disappeared, owing evidently to the immense radiation from the surface, as rain still fell both north, south, and west. This effect was much more noticeable during 1867 and the early part of 1868 than afterwards; the heavy rain-fall of July of that year caused a great growth of grass, &c., to cover large tracts that were before quite bare, which checked the radiation so that the clouds no longer disappeared, but at all times the greater part of the rain fell at night or during early morning.

The barometer that I had was an aneroid which I got from on board a ship, and except on three occasions noted above registered 29·95 inches at 9 a.m. This is about 0·11 inches higher than the usual reading within the tropics, the difference being no doubt due to the barometer itself, but as it got broken coming here I had no opportunity of comparing it.

The variations of the thermometer in the shade were extremely regular. At daybreak it stood at 80°, from which it gradually rose till between 9 and 10 a.m. when it stood at 96°, at which point it stood until shortly after sunset when it gradually fell to 80° at 10 p.m., at which temperature it stood till morning. The only exceptions to this regular routine were on the 4th October, 1868, when with wind due south and heavy rain, the thermometer recorded 77° F. at daybreak, the temperature of the rain being 73° F. On October 11th, at daybreak, 77° F., raining, wind E. On December 1st, at 11 a.m., raining, 84° F. all day; and from the 16th January, 1869 to 29th, inclusive, the thermometer never rose above 82°, there being continuous rain and no sun visible for thirteen days, with the wind due west. Hanging in the sun, and freely exposed to the wind, the unblackened thermometer gave at different times readings from 103° to 106°, and covered with one inch of soil, light grey in colour, it rose to from 125° to 135° in the afternoon. As I had only one thermometer these temperatures could not be often taken for fear of breakage.

Evaporation was not observed with regularity, but an average of eight days ending 11th December, 1868, gave 0·387 inches per day.

Wind:—In the beginning of October the wind was generally light east with calms, and the north-east trades began about the middle of the month, varying from E. to N.E. till the end of February, when light winds and calms again occurred, followed by S.E. and E. trades till October. The only exceptions to this were on October 1st, 1868, when the wind was due south. From the 14th to 31st December there was a dead calm with very heavy sea for the last three days, and from the 16th to 25th January, 1869, the wind was strong westerly. The island was not large enough to check the trade wind, so that at night there was almost always a dead calm at the west end whilst there was occasionally a barely perceptible movement from the sea.

The set of the currents round the island was altered at the same time that the wind changed from N.E. to S.E., and this change was marked by the movement of an immense mass of sand forming the west beach. In the beginning of March the sand began to accumulate on the beach and continued to do so until the beginning of October, forming a beach about 120 feet wide by 9 feet high, and a mile long. When the sun crossed the zenith of the island almost to a day this sand began to move to the south, where it was piled up for some distance along the south beach until all that the waves could reach was removed, and it was again brought back as soon as the sun crossed the zenith going north. In a great tidal disturbance in the end of December, 1868, the greater portion of this sand was washed away into deep water and disappeared.

The tide rose at springs about 2 feet, and it was high-water about 4 p.m. at the full and change of the moon, at which times there was generally a heavy swell on the west beach, and either the south or north according to whether the trades were N.E. or S.E.—the swell being on the opposite side to the wind.

The zodiacal light was nearly always to be seen, but was not noticeable for brilliancy.

The botany of the island was limited to ten species. The low ground near the small lagoons was covered by a thick-leaved species of mesembriantheum, whilst the bank was generally covered with a portulaca growing about 18 inches high. These, with the kupatca-tree, formed the principal vegetation; but there were also a small yellow-flowered malva, a marygold, three grasses, a yellow-flowered and a white-flowered plant which I am not botanist enough to identify. On the reef, turtle weed and a small coralline grew sparingly, and there was afterwards introduced on ballast stone from New Zealand a green weed which grew with great vigour and seemed likely to soon cover the whole of the reefs, growing over and killing the corals.

The soil on the banks on which these plants grew, and that luxuriantly when there was rain, gave on analysis when air-dried—

Water	6·24	or	Water	6·24
Organic matter	5·01		Organic matter	5·01
Lime	46·23		Phosphate of calcium	·50
Magnesia	2·07		Posphate of calcium	7·57
Alumina and oxide of iron	0·21		Sulphate "	1·93
Phosphoric anhyd.	3·84		Carbonate "	74·34
Sulphuric "	1·14		Carbonate magnesium	4·34
Carbonic "	35·49		Silica	·21
Silica	·21			
Chlorine and alkalies	(Traces)			100·14
	100·44			

In this analysis the phosphoric acid was separated from the ammonia precipitate by G. H. Rose's method. The matter insoluble in acid, from a considerable portion examined microscopically, was found to consist principally of minute fragments of pumice, with a few diatoms and sponge spicules. The soil on which the mesembriantheum grew was actually a poor guano, which, washed free from salt-water with which it was saturated, contained—

Water and organic matter	35·56
Phosphate of calcium	13·79
Sulphate " "	6·02
Carbonate " "	43·21
Carbonate magnesium and loss	1·42
	100·00

ANIMALS.

Of the animals inhabiting the island there were twenty-two, and five birds which were occasional visitors.

Five of these were insects. 1st. The common house-fly, which is found on all islands that are or have been inhabited, but not on uninhabited ones. 2. A small blow-fly. 3. A minute red ant. 4. A beetle, a species of dermestes. 5. A large moth, which was sometimes very rare, but after continued rain became very abundant, the whole island being covered with caterpillars. All the birds had also one or more species of parasites living on them.

There were two species of lizards; a bright-coloured one, about 6 inches long, rejoicing in the sunshine, and a dull-coloured geko, much shorter, living in dark corners.

Of quadrupeds there was only one example, a small species of rat, which was more than sufficiently numerous.

Of the birds, the five occasional visitors were—a small petrel; a dark grey duck; a bird somewhat like a kestrel hawk, which

lived on lizards; a snipe or sandpiper, and curlew. The two last were almost always on the island, either on the edge of the reef or near the small lagoons, but they did not breed there.

Of the fourteen birds that breed on the island there were three species of prians, slate-coloured, pure white, and black. Three súlus or boobies, white, black, and grey. Three puffinas or mutton birds. One crow. Two terns, or wide-awakes. The tropic bird, phaeton, and the frigate bird, *Tachepetes aquilis*. Of these birds the only one which built a nest was the grey booby, which it did either on the branches of trees or on the low marshy lands near the small lagoons, where the nests by successive additions formed small cones about 18 inches high. The frigate bird seemed at times to have a vague idea that a nest would be an improvement, and collected half a dozen twigs, but then turned tired of it and laid on the ground. The boobies frequently lay two eggs and sit on them, but I never saw more than one young one; all the other birds lay one only. The mutton birds in holes dug in soft ground or between rocks, and there the tropic bird also rears her black and white young one.

The prians lay on the edge of a rock or stone, and the egg being of exactly the same colour is only seen with difficulty; they are quickly hatched, and in ten days the young have flown.

The most numerous birds are the black wide-awake and the frigate bird, and it is to them that the deposits of guano on the island are principally due.

The wide-awake lays on the sloping bank twice a year, in October and April, under the shelter of plants of portulaca. In the end of September the flock begins to collect, flying high in the air above the spot where they intend to lay, a constant stream of birds flying to and fro between the flock and the sea. Day by day the immense flock flies lower and lower, till about the 22nd or 23rd of October they are skimming closely along the ground; up to this time there are no eggs to be found, even up to 3 o'clock of that day. The flock then evidently diminishes in number—the birds are down, an event which was looked forward to with some anxiety, and by 4 o'clock there is an egg to every square foot of surface. On my first arrival on the island the flock would in this way cover 5 acres of ground, but in 2½ years the number had been reduced to one-fifth, principally in consequence of cats which had run wild and increased with extraordinary rapidity. The bird seems only to lay one egg and hatch it, but if that is taken away, in a few days another is laid in the same place, unless the flock has been too much disturbed, when they desert all the eggs and remove to some other place and then lay again. The young ones begin to be hatched in fifteen or sixteen days and remain nearly three months on the ground, being fed by the parents principally on squid and small flying-fish.

The frigate birds lay principally on the level ground where the portulaca grows short, and they remain nearly constantly at the same spot whether laying or not. They lay in December and June one large white egg remarkable for the very small size of the yolk. Compared with a fowl's egg, I find the yolk of this bird to weigh 280 grs., the white 850 grs., whilst in the fowl's egg the yolk weighed 263 grs., the albumen 424 grs., the proportions being 1 : 3 and 1 : 1·6. At the breeding time the cocks have large scarlet pouches under their necks, which they inflate when roosting. These are about 5 inches in diameter, and to see an acre or two covered with birds, every alternate one with his pouch inflated, and contrasted with his glossy black feathers, forms a fine sight; when flying they usually allow the pouch to collapse. These birds are the terror of all others; the boobies coming home laden with fish are pursued remorselessly by them as long as they remain in the air, and sometimes taken by the wing or tail and turned upside down to make them disgorge part of their booty, which the frigate bird generally catches dexterously before it reaches the water or ground. The young of the other birds also frequently fall a prey to them when left unguarded whilst still small enough to be swallowed, and if a flock of frigate birds having callow young are disturbed, the birds in the air swoop down on one another's young, which they carry up into the air, let them drop a few yards, and again catch and swallow them. If a flock of wide-awakes has settled near a clump of trees about the time of hatching, the frigate birds roost on the branches looking out for any chicks that may be left for a moment unprotected. This bird never seems to sit on the ground except when hatching, always roosting on a twig or stone, where they remain for hours together preening themselves with their eyes shut. Immediately on the appearance of a shower of rain they soar high into the air into the shower, and frequently follow a small rain-cloud for many miles.

The puffinas are remarkable for the extreme regularity of their movements, starting at 4 a.m. for their fishing grounds with the greatest punctuality. Before that time all is quiet, when almost to a minute the air is filled with their cries, and by daybreak or shortly after they have disappeared. At 4 p.m. they begin to return and sport noisily in the air till sunset, when they retire to their holes.

The flesh of most of these birds is strong-tasted, but the pectoral muscles of the frigate and tropic birds which are never fat are very good if cooked separate from the bones, whilst the eggs of the wide-awake are excellent.

The signs of previous habitation were sufficiently numerous. There were three mareas built of coral rock slabs set on edge and filled in with loose blocks and shingle to a level surface about 2 feet above the level of the ground. One of them was about

30 feet by 12, and was surrounded at a distance of a few yards by lines of coral slabs set in the ground, about 6 inches projecting above the surface.

There were numerous kitchen heaps composed of ashes and ignited stones, which are used in the Kanaka mode of cooking. Many of these were of large size, and judging from the insignificance of the similar heaps produced by the Kanakas employed on the island must have been the accumulation of many generations, so that it seems probable that the island was inhabited by a few families for a long period. Near the kitchen heaps in several places were wells (seven in all) sunk to a depth of 2½ feet, and carefully faced with coral slabs, but I never saw any water in them, and on sinking one a foot deeper salt-water only was obtained. It was evident that fresh water had always been very scarce, as everywhere that a small hollow occurred in the rocks which would collect and retain rain-water, it was covered by one or more slabs of coral to protect the water from the sun. These hollows had in most cases become filled with guano dust, and on clearing this out I generally found the belly whorl of a cassis or dolium which had been kept there as a drinking vessel.

Opposite all the kitchen heaps along the north and south banks, and at some intermediate places, the ridges had been levelled to form pathways to the reef, and flat slabs had been laid down forming a line of stepping-stones. The cutting and stepping-stones extended over the six inner ridges, whilst the three outer ones were invariably as formed by the waves, forming a record at present unreadable of the desertion of the island.

In one spot there was a rude attempt at architecture, several coral slabs being set on edge and covered by other slabs laid horizontally, forming two dens about 4 feet cube, with entrances 18 inches wide. There had apparently been others at the same place which had fallen into disrepair.

There were numerous graves surrounded by upright coral slabs. I opened several of these, but was not successful in finding any remains in them; but another gentleman was more successful, the first grave he opened yielding a skull and tibia of a man who from the length of this bone must have been nearly 6 feet high. In the same grave were a hatchet-head with polished edge made from the shell of a tridacna; two chisel-like tools formed of the outer lip of cassis polished to an edge at one end; and a neck-pendant from the inner lip of the same shell well cut to an acuminate ovate form, and bored at the wide end for suspension by a cord. In many places there were numerous axe-heads chipped roughly out of tridacna shells. These are tolerably easily made, the shell being first broken transversely, when a blow on the fractured surface breaks out from the interior of the shell an adze-shaped piece which seems to me to be the pattern on which many of the South Sea stone adzes are formed.

The Guano and other Phosphatic Deposits occurring on Malden Island.

By W. A. Dixon, F.C.S.

[*Read before the Royal Society of N.S.W., 3 October, 1877.*]

The guano deposits on Malden Island are entirely phosphatic, and occur either on the spot where deposited by the birds, or in crevices and pockets amongst the rocks, where it seems to have been washed by water or blown by the wind, or possibly it may have been there deposited anterior to the occupation of the island by natives. The former deposits are of comparatively small extent, but are very rich in phosphoric acid, whilst the latter are very extensive, but vary much in value—much of it being too poor to bear the cost of removal.

Having left the island rather hurriedly, owing to a severe illness, I unfortunately lost a note-book containing analyses of the different deposits, phosphatic minerals, plant-ashes, &c., and have therefore to fall back on some analyses in a rough note-book, made by an expeditious method, for the purpose of ascertaining what deposits were worth working. After ignition to expel organic matter and water, the process used was, to dissolve the ash in a minimum of hydrochloric acid, precipitate tricalcic phosphate by ammonia, re-dissolve the washed precipitate, and after addition of a small quantity of tartaric acid, re-precipitate with ammonia and weigh as tricalcic phosphate—the ash being tested to ensure the absence of carbonate. This process, though not absolutely accurate, gives much better results than it is usually credited with, when fluorine and soluble silica are absent and the quantity of alumina and ferric oxide present are small.* The first were never found in any of these deposits, and the last two together never amounted to more than 0·25 per cent.†

The following analyses show the general composition of the recent guanos by this method :—

Recent Guano—Wide-awake (Tern).

Water and organic matter	10·41	14·10
Calcium phosphate	72·49	79·21
,, carbonate	9·32	4·19
,, sulphate	5·82	2·17
Magnesium carbonate, alkalies, sand, and loss	1·96	·33
	100·00	100·00

* See H. Pellet, Bull. Soc. Chim. [2] XVII, 105; and Chem. Soc. Jour. [2] XVI, 578.

† See also Fettbogen, Chem. Soc., Jour. [2] X, 1,112; and Voelker, Jour. Roy. Agri. Soc. [2] XII, 440.

Frigate Bird (*Tachypetes*) Guano (recent).

Water and organic matter	11·41	9·75
Calcium phosphate	84·34	81·91
,, carbonate	3·12	7·01
,, sulphate	·79	·98
Magnesium carbonate, alkalies, sand, and loss	·34	·35
	100·00	100·00

The organic matter present consisted principally of roots of plants, and yielded very small quantities of nitrogen. The removal of the nitrogenous organic matter appears, on this island at all events, to be principally due to the action of the heat of the sun, and not to rain, which is the cause usually assigned. Whilst the birds were on the ground, there was a considerable evolution of ammonia; but this disappeared entirely before they again laid, there being an interval of three months during which the ground was unoccupied. This occurred during my residence on the island—once when there was no rain in the interval, once when 0·263 inches fell in six showers, and once when 0·812 inches fell in seven showers—the heaviest being 0·4 inches, which fell about two or three days after the birds left the ground, and in each case the nitrogenous matter had disappeared before they returned. The guano seems not to be deposited fast enough for the recent upper layers to protect the lower.

The guanos deposited by the mutton birds (puffinas) was always poor in phosphates, as they principally inhabited ground where dust—composed of carbonate and sulphate of calcium, deposited by the evaporation of the water of the lagoon—is deposited by the wind. By their continual burrowing they also bring up to the surface portions of the same substance, which has been deposited before they took possession of the ground. The following shows the composition of some of this guano:—

Water and organic matter	21·66	26·24	26·31
Phosphate of calcium	40·90	54·36	55·74
Insoluble		....	·21

The old guano is found on the low ground, a little inside the encircling ridge, and the surface is about 3 feet above water level. The deposits are nearly level on the surface, but, on digging, projecting rocks are laid bare which enclose pockets of guano. The immediate surface is never of any value, being largely contaminated with calcium carbonate; and the richness in phosphates increases with the depth. When the pockets did not extend down to the water level, the bottom was lined with an indurated guano very rich in phosphates (crust guano of Voelker, *loc. cit.*) Of this I

have recently obtained a specimen, of which the following is an analysis, the phosphoric acid being separated by Rose's method :—

Water	2·60
Organic matter and combined water	6·45
Phosphoric acid	43·04
Sulphuric acid	·62
Carbonic acid	(Traces)
Lime	43·45
Magnesia	3·97
Ferric oxide and alumina	(Traces)
	100·13

In this (as in most other analyses that I have made of the same material) both calcium and magnesium phosphates are present.

Where the pockets descended below the water level, on the other hand, when this was attained the material altered in appearance, from being a soft yellow-brown powder (when removed and allowed to dry) to hard grains of a chocolate-brown colour, whilst the rocks were found incrusted with a hard chocolate-brown substance interspersed with minute white specks. This incrustation from being very thin a foot above the water level, gradually increased to a thickness of five or six inches when that level was attained, whilst the coral rock beneath it was often completely disintegrated—so much so that on removing the crust it formed a milky mixture with the water. This incrustation was principally composed of calcic phosphate, magnesium phosphate being absent. It gave a slight effervescence with acid, which apparently arose entirely from the white specks. Its fracture was slightly choncoidal, it gave a yellow-brown powder, and was very hard.

The following numbers show the composition of the different layers from the surface downwards—the material being taken as dug out—so that they contain all the water, of which from 14 per cent. to 16 per cent. dried out on exposure to the air. The fields from which the different samples were obtained were about three-quarters of a mile apart :—

		1st Field.	2nd Field.
Top 6 inches of guano.	Loss on ignition	24·31	23·51
	Calcic phosphate	28·67	34·24
From 6 inches down to water-level	Loss on ignition	26·24	16·80
	Calcic phosphate	54·36	63·10
Shotty phosphate to 18 inches below W. L.	Loss on ignition	24·70	23·61
	Calcic phosphate	71·85	72·53
Incrusting stone phosphate	Loss on ignition	8·25	6.31
	Calcic phosphate	86·05	87·59

Deducting from each of these the percentage of volatile matter, to make the increase more evident, the residues would contain of calcic phosphate—

Top 6 inches	37·8 ...	44·7
From 6 inches to water level	73·5 ...	74·6
From water level to 18 inches below ...	95·2 ...	94·9
Stone phosphate	93·7 ...	93·4

I have lately tried to discover the mode of formation of the stone phosphate, but without any very satisfactory result. Tricalcic phosphate in solution in water saturated with carbonic acid, I find, does not deposit any by prolonged contact with calcium carbonate, and this result is not altered by the presence of any of the salts present in sea-water; neither does a cold saturated solution of magnesium phosphate charged with carbonic acid, shaken up with precipitated tricalcic phosphate and the clear solution digested with calcium carbonate, deposit any phosphoric acid, although in all cases calcium carbonate was found in solution. A mixture of tricalcic phosphate and dimagnesic phosphate, both in excess, treated with carbonic acid, and the filtered solution digested with calcium carbonate, the carbonic acid not being allowed to escape, deposits traces of both magnesia and phosphoric acid, but in no case did the phosphoric acid deposited amount to more than 2 per cent. of that contained in solution.

It seems probable, however, that they are formed by the action of sea-water on an indurated guano, the sulphate of calcium converting the magnesic phosphate into calcic phosphate, whilst the carbonic acid generated by the slow decomposition of organic matter removes calcium carbonate in solution.

In most places where the natural coral rock projected above the surface, it was covered by a pale bluish grey coating or skin, which although extremely thin was perfectly impervious to water, so that rain collecting in any hollows remained there until evaporated; but if this skin was broken through at the bottom of a hollow, the water rapidly percolated away. This coating was in some places hard enough to strike fire with the point of a pick; it did not effervesce with acids, and was apparently entirely composed of calcic phosphate.

Amongst the recent guano deposits any loose stones were found to be similarly incrusted with calcium phosphate, which had in many cases penetrated the stone to a considerable depth, sometimes entirely so. They were found on the surface of the guano, and not buried amongst it. Several of these stones ground up together gave the result No. 1, whilst a single stone which did not effervesce on the surface, and was sonorous when struck, gave No. 2.

	No. 1.	No. 2.
Loss on ignition	15·25	12·00
Calcium phosphate	48·50	71·15.

It is evident that the general incrustation on the surface of the rocks and on these stones was formed by the direct action of the excrement of the birds, the stones being in fact pseudomorphs, as there were abundance of similar pieces of coral shingle elsewhere, the only difference in appearance being in their colour.

Discussion.

Mr. Russell asked Mr. Dixon if he thought the inhabitants had been driven away by some great drought. It had been stated with regard to another island that there had been no rain on the island for years, but that while the crew of a vessel were there, to their utter surprise it came on to rain for three months, and the island became covered with grasses.

Mr. Dixon said that four years before the year 1866 there was abundance of rain, and one man said the whole place was like a meadow—that was in 1862. Some, however, thought that nonsense. In 1863, 1864, 1865, 1866, 1867, and 1868, there was no sign of any such thing, but in 1869 there was abundance of rain, and the place was like a meadow.

Mr. Russell: And you saw it?

Mr. Dixon: Yes. Only one man had seen the previous wet season; the others said there was never any rain at all; but I believed what was said, that there was sometimes rain, and I built a tank, and it was filled with one night's rain. I believe, however, that they have now again got into a rainy season; and when a rainy season sets in, the place is very unhealthy. It strikes me that as cats and pigs can live on the island without water, perhaps the Kanakas can also. We turned out some pigs and goats, and they wandered about the island for eleven or twelve months and lived without water. Some of the cats ran wild. The rats got so numerous that we used to kill them in thousands; in the store we killed some twenty thousand in two months.

A member said, if they were to dig down a few inches, could they get water?

Mr. Dixon said they never found any fresh water in the Kanakas' wells. The nearest inhabited island is distant about 600 miles.

Mr. Moore said the existence of the species of plants described indicated long periods of drought, but the existence of grasses seemed to be extraordinary: it proved that the seeds must retain their vitality for a long period. It was very singular that the grasses should spring up so rapidly and cover the surface.

Mr. Dixon: The place was smooth and level, like a floor; it was quite salt on the surface, and yet the seeds germinated.

Mr. Moore: There are many grasses that grow absolutely in salt water.

The Chairman: Is all the guano removed?

Mr. Dixon: No. They still keep removing it. The deposits are very uncertain and scattered.

The Chairman conveyed the thanks of the meeting to Mr. Dixon for his interesting papers.

On some Australian Tertiary Corals.

By the Rev. J. E. Tenison-Woods, F.G.S.; Hon. Mem. R.S. N.S.W., Tasmania, Adelaide Phil. Soc.; Corr. Memb. R.S. Victoria, Linn. Soc. N.S.W., &c., &c.

[*Read before the Royal Society of N.S.W., 7 November*, 1877.]

The subject of the Australian fossil corals has occupied much attention among geologists of late years. Deep-sea dredging has brought them into prominent notice, for not only have several missing links of past palæontological history been thus discovered, but our fossils have been found to possess remarkable features of their own and remarkable affinities with fossils in remote places. It was in 1865 that attention was first drawn to them by Prof. Duncan, at present holding the honorable position of President of the Royal Geological Society of London. In the year referred to he published in the *Annals of Nat. History* the results of his examination of a small parcel of corals sent by me to him, from the tertiary beds of Muddy Creek in Western Victoria. It was supposed at the time that some of them came from Mount Gambier, but this was not the case. The Mount Gambier limestones are singularly destitute of corals, though they are wonderfully rich in Polyzoa. They all came from the bed of argillaceous limestone which underlies the basalts at Muddy Creek about 5 miles from Hamilton in Western Victoria. The result of Prof. Duncan's examination was that seven or eight new species were added to science, all of which possessed features of singular interest, with the usual array of Australian "*abnormalities*" as they are called. The relations were mostly with Miocene forms, and the living species among them were Australian but tropical. Prof. Duncan's researches were followed up by a very elaborate monograph in the *Proc. of the Geological Society of London* for 1870, in which he not only gave a complete review of all the species known to him and several new ones which he added, but he exhaustively dealt with their affinities and entered largely into the whole question of Australian Tertiary geology. By this means we became acquainted with many new species and two new genera, including *Flabellum*, *Placotrochus*, *Sphenotrochus*, *Conotrochus*, *Trochocyathus*, *Deltocyathus*, *Caryophyllia*, *Palæoseris*, *Amphehelia*, and *Balanophyllia*. Subsequently I was enabled to examine the fossils of Table Cape, Tasmania, a parcel of corals

from which yielded many of the Australian forms, and Prof. Duncan was enabled to add two entirely new species of genera not hitherto found, namely, *Dendrophyllia* and *Thamnastræa*. What gave especial interest to these forms were, that they were reef-builders, whereas all the other species described were small pedicellate solitary corals (with the exception of *Amphihelia*) living at moderate depths at the bottom of the ocean.

Up to this time I have always been enabled to send to the learned Professor Duncan all my collections in this particular department, and here am glad to acknowledge with what courtesy and painstaking industry he has always addressed himself to their examination. I regret that I am not now able to avail myself of his aid. But latterly I have found in various public and private museums specimens which I am unable to send away for determination, and therefore am obliged, though fully aware of my own deficiencies for such a task, to undertake their investigation and description. I think it due to science to state that I feel my insufficiency, and the great help I shall receive from what my predecessor in this matter has done, without which I would not undertake it at all.

I must here state, for the information of my readers in Australia, that this branch of Natural History, the Corals, has been very carefully worked out of late years. The great standard authority of the subject is the *Hist. Nat. des Coralliaires, by Milne Edwards and Jules Haime* (3 vols. 8vo., with atlas), but the student must also receive large help from the various elaborate essays in the *Annales des Sciences Naturelles* (from 1848 upwards) by the same authors, and their monograph in the publications of the Palæontographical Society on British Fossil Corals. There is also a most complete treatise on the stony corals, by Prof. Duncan, in a late number of same Society's Monographs, which contains drawings and definitions of the various organs and terms in use. These leave but little to be desired, and with the aid of them determination of genera and species becomes a comparatively easy task. The literature of the Corals is very rich, including as it does the valuable researches of Peyssonel, Pallas, Savigny, Lamarck, and Lamouroux, and our own countryman Ellis, whose work (*Essay towards a Natural History of Corallines, London*, 1754) may still be consulted with advantage. I am glad to add that there are copies of these rare volumes in the Museum Library and in that of Mr. Macleay. It was not however until 1828 that any attempt at classification was made, founded upon the anatomy. This was commenced by Messrs. Milne Edwards and Audouin. They were the first to separate from the corals proper the more highly organized polyzoa and the much lower class of sponges. M. Cuvier about the same time showed the close relation between the actinæ or jelly-fish and the corals. Of late years, a great

development has been given to all previous investigations by the labours of the eminent American naturalist Dana, whose work on the Zoophytes of Wilkes's United States Exploring Expeditions (1 *vol. 4to., Philadelphia*, 1846; *atlas fol.*, 1849) forms an epoch in the science. It may be as well to mention, for the information of students, that many important extracts from this work are given in *Silliman's American Journal of Sciences*.

My object in referring to the history of the classification of this order, is for the purpose of pointing out the modifications which an extended knowledge of Australian corals is likely to introduce. The complete work of Messrs. M. Edwards and Haime forms now the basis of the received systems in arranging the genera and families of corals; and though it is really a wonderful monument to the industry and sagacity—I may add genius—of the authors, yet I think most naturalists feel how artificial and arbitrary the system is. This must be the case with all systems, and in the corals, where we have so little to go upon—so few features upon which to erect generic and specific differences—it must be always felt. The difficulty that occurs to me is in determining the presence or absence of organs upon which generic distinctions are made to rest. Thus, in the *Turbinolidæ*, we have sub-family distinctions built on the presence or absence of pali, and this again made of generic value by their number, the presence or absence of a columella, its form, the costæ, &c. In the next group we have the first great divisions made upon the presence or absence of an epitheca, then comes the form of the columella, the adherence, &c. Now, in some of these particulars the Tertiary corals of Australia, and some of the recent forms which I am describing, unite the characters of two or three genera (*Conosmilia* &c.), or show gradations in structure which make the line of divisions exceedingly difficult to draw. Then again, we find peculiarities of structure which belong to a certain genus, though not essentially forming a basis for classification, reappearing in other genera which are remote in our present system. Take, for instance, the costal features. In the *Turbinolidæ* we find a very peculiar structure in five or six species. There are only three cycles of septa, while on the outside there is a very regular development of costæ, exactly like modified septa, only that there is one cycle more than the septa of the calice, and consequently we have a rib or septum on the outside without any septum on the inside to correspond with it. This will appear the more extraordinary if we call to mind what is the doctrine with regard to the costæ, and I must be pardoned for making an extract from Messrs M. E. and H.'s work (*Nat. Hist. des Cor.*, vol. 1, p. 58). "The *wall* not only gives origin to centripetal prolongations which we call septa, but bears also in most cases projections or laminæ analogous to the septa, which develop themselves in a contrary direction, and which we call

costæ. These parts are susceptible of the same modifications as the septa, and are in fact only the exterior continuation of them, which is easily seen by examining the *Turbinolidæ*, *Phyllangia americana*, *Heliastræa Forskaliana*, and many other corals simple and compound. All that has been said of the septa, therefore, is true of the costæ as to their relative positions and modes of multiplication. Nevertheless, in certain rare cases, *Stephanophyllia* and *Micrabacia*, the costæ alternate with the external edge of the septa as if the two leaves which compose the edge of these were divided exteriorly from one another to unite with the external leaf of the neighbouring septum. On the other hand, in *Dasmia* one single rib corresponds with three septa. But these facts are exceptional, and nearly always the costæ are only distinguishable from the septa by their position outside the wall."

Now in our Australian corals we find that a very large proportion form an exception to this rule. The costæ do not correspond with the septa, but exceed them in number. If this took place in one genus alone, as it does in *Turbinolidæ*, we might not wonder so much, but it appears in remote genera. Thus we have this feature manifested in a marked manner in our living *Conocyathus sulcatus*, and, as I shall show in a species now to be described, it occurs in another species, and in a *Ceratotrochus*. In this case it seems as if the coral animal had its support on the outside. The existence of the septa is intimately connected with tentacles of the animal, and their number coincides exactly with those appendages. It is not known, or has it I believe been studied, what relation the costæ bear to the living animal. Fortunately there is one form yet surviving where the peculiar structure to which I refer can be seen, and naturalists of Sydney may make it well worth their while to ascertain the anatomical structure of *Conocyathus sulcatus*, which is so common at the mouth of the harbour.

I cannot however help raising the question as to the importance of the costæ in the matter of classification. It seems to me that where costæ predominate over the cycla, that in itself is a natural feature in the *Turbinolidæ* which should override minor details of the columella and so forth. We should thus group together corals whose living habits would probably be found to correspond, and we should not see, as we do now, corals which are closely united in one conspicuous feature distributed through three or four different genera. Distinctions founded on the columella and pali are most unsatisfactory: in very many cases it is impossible to distinguish between pali and a fasciculate columella; in others it depends much upon our fancy whether we describe the coral as without pali but with deeply lobed septa, or with pali attached to the septa. I make these remarks with the utmost diffidence, and not attempting to cause any confusion by creating new divisions, only let it be borne in mind that they

are of importance, when we remember how badly preserved and how worn fossils often are from which new species and genera are created. A little wearing down may make a world of difference, when the classification rests on slight details. This department of Natural History still awaits its Linnæus to found a system that all would accept. We have not it is true those definite organs with ascertained functions that botanists possess, and probably we shall not have until the living animals are better understood. For most of our corals we must resign all hope of any further study than that which the stony portion will furnish, as the majority have flourished as past beauties of the earth's history, and are only known now as fossils. But light, and much light will come from those which still live, and probably for this we must wait. In the meantime I have drawn attention to these points, that abler and more learned naturalists may follow up.

I now proceed to describe the new species which I have to bring under the notice of the Society. They are all from Muddy Creek, near Hamilton, Western Victoria. I made a visit to that locality in December of last year, but was unfortunately taken ill while at the hospitable station of Mr. S. P. Winter of the Wannon, and so was obliged to content myself with two small boxes of clay from the edge of the creek which Mr. Winter's brother brought to me. These have been most industriously searched and sorted by Mr. Ramsay, the learned and zealous Curator of the Museum, and they have yielded many novelties. The corals were few, except the well known so called *Caryophyllia viola*, Duncan, which was very abundant, and which with a few specimens of a new species were the only *Caryophyllaceæ* present. The other genera were *Conocyathus*, *Sphenotrochus*, *Smilotrochus*, and *Conosmilia*, all of new and remarkable forms. I have been obliged to place in another genus, Prof. Duncan's *Caryophyllia*, and some other species since discovered, for reasons which will appear.

MADREPORARIA APOROSA. *Fam.* TURBINOLIDÆ.

Genus CERATOTROCHUS. *Edw. & Haime*, 1848.

Corallum, simple, free in adult state. Columella highly developed and fascicular; septa large and exsert; wall without any epitheca, presenting costæ which are distinct to the base, the principal being ornamented. Fossil only and tertiary—Miocene of Italy, Pliocene of Tuscany, Eocene of India. This genus was erected for species, all of which are highly ornamented with spines and crests, which is imperfectly represented in a worn specimen of doubtful character, the diagnosis of which I reserve for examples in better preservation.

Genus CONOCYATHUS. *D'Orb.*, 1849.

Corallum, simple, trochoid, straight, free, without trace of adherence, septa exsert, very granular, costæ prominent, no columella, pali before penultimate cycle.

We have only had one fossil species of this genus in the Miocene of Europe, but which has lately been found living at Port Jackson. I believe it to be distinct, and this opinion is strengthened by the curious discovery of two other species in our Miocene deposits.

CONOCYATHUS CYCLOCOSTATUS, N. S.—Corallum, cuneiform, very much compressed at the base, which is roundly or bluntly pointed and without trace of adherence. Costæ numerous, forming four cycla closely set, rounded but scarcely projecting, and without trace of ornament, the secondary ones beginning at the base and being with the first thicker at their origin, becoming thin higher up. Tertiary costæ begin also a short distance from the base, but those of the fourth order at about a third, and the fifth near the edge of the calice; intercostal spaces narrower than the costæ, not deep, and between the higher orders furnished with a single series of faint pits, calice broadly elliptical. There is no calicular fossa, as the six stout pali unite in the centre at the summit of the corallum; septa in six systems of three cycla, all equal, exsert, reaching to the pali but slightly united with them; the primaries very flexuous at the inner edge and all highly granular; pali very conspicuous, forming six very flexuous large irregular rounded lobes. There are no septa to correspond with the fourth cycle of costæ, but the wall bends outward from each septum so as to form the rib. In very young specimens the first order of the fourth cycle of costæ is not visible, in which case the wall bends outwards the fourth. Alt., 6; maj. axis of calice, 3; min., 2 millim. Not very common.

CONOCYATHUS FENESTRATUS. N. S. Corallum, conical, the transverse section being perfectly circular. Costæ in three cycla, primaries undivided to the base, prominent, very granular and subspinous; second and third orders dividing near the base, intercostal spaces deep, marked with a regular series of deep pits, by transverse processes from the costæ sometimes reaching from side to side; septa in two cycla of six systems, exsert granular, primary and secondary equal, two only continuous with the exterior costæ, pali small, papillary, inconspicuous. Alt. 7, min.; 3 millim. Very rare.

Genus PLACOTROCHUS. *Ed. & Haime*, 1848.

Corallum, simple, free, but often with traces of adherence, straight and compressed, calice elliptical, with a straight lamellar columella, crenulate, extended in the direction of the major axis; septa very slightly exsert, either smooth, papillose, or granulous, costæ covered with a thin pellicular epitheca.

PLACOTROCHUS ELEGANS.—Corallum, minute, broadly wedge-shaped, laterally compressed, elliptical, major axis of summit not much exceeding the base, while the minor is nearly equal throughout; base convex, with a salient angle almost tubercular at each side; sides regularly convex, white, smooth, and shining; costæ corresponding to the septa; the primaries and secondaries of equal width, broad and smooth, ending in a broad point at the calice and continuing to the base, only slightly narrowing; tertiaries inserted between, arising about a third from the base, narrow and ending in a point, giving the calicular margin a regularly serrated edge with large and small teeth alternating. Calicular fossa narrow and deep; septa of three cycla in six systems, slightly exsert, very granular, primaries and secondaries equal, with a tortuous entire edge which stops short two-thirds from the centre, leaving a deep fossa in which the thin straight columella is very conspicuous, though it does not rise to the level of the septa. Alt., 3; maj. axis, 3, min., $1\frac{1}{2}$; diam. of base, 2 millim. Rare. (*Plate I, fig.* 1 *and fig.* 1*a.*)

Genus SPHENOTROCHUS. *Mil. Ed. & H.*, 1848.

Corallum, simple, free, without trace of adherence, straight, and cuneiform; columella and septa like *Placotrochus; no epitheca;* costæ generally distinct and simple, granular, or crisped.

SPHENOTROCHUS VARIOLARIS, N.S. Corallum, wedge-shaped, short, very much compressed inferiorly, and the base has two obtusely angled shallow notches dividing it into three equal parts. The section of the summit is elliptical, the major axis being more than twice the diameter of the minor. There are no costæ, but instead the whole surface has a finely spongy texture of irregular papillæ and pores. The calice is deep, and lower at both ends. Septa in six systems of three cycla, the primaries and secondaries smaller than the tertiaries and the systems at the ends incomplete. Columella finely laminar and very distinct; the primaries and some of the secondaries uniting with it simply. All the laminæ granular, and the granules arranged at the exsert rounded edges of the primaries, in radiating lines. Alt., 9; maj. axis, 7; min., 3. Not very common.

This fossil derives special interest from the fact that it still exists on the east coast, some fine specimens having been dredged by Mr. Macleay off Port Stephens at a depth of 70 fathoms. M. Milne Edwards remarks that the Sphenotrochi whose costæ are crisped or papillary are peculiar to the Eocene formation, while of the species which have smooth costæ one belongs to the present period, three to the Miocene, and only one in the older beds. This species has the costæ distinct and papillary in the young state, but as it gets older the papillæ get worn off, and become pitted, depressed, or like worm-eaten holes. (*Plate II, fig.* 4.)

The alliances of this species are therefore Eocene or older tertiary, and had it not been found living would have tended to swell the evidence in favour of the greater age of the deposits to which it belongs,—a kind of evidence, however, which this instance shows must be received with great caution, and not at best possessing much weight.

Sphenotrochus variolaris is remotely allied to *S. australis*, Dunc., of Muddy Creek and Geelong, but differing in the absence of costæ and the form of the base. The arrangement of the septa is near to *S. australis*, in very many peculiarities, but the base is very different. The costæ and twelve of the septa unite with the columella, but in *S. variolaris* only ten. In the young specimens the exterior is quite covered with fine papillary projections, and there is no laminary columella, but only a loose reticulated mass. From this we must conclude that the columella is not essential or does not rise from the base.

Genus Smilotrochus. Milne Edward and Haime, 1851. Corallum, simple, straight, cuneiform, free and without a trace of adherence. No columella, septa finely granular, slightly exsert and touching by their inner edge. Wall naked, with simple costæ distinct to the base. (*Plate II, fig.* 2 *and fig.* 2*a*.)

All the specimens known to Edwd. and H. belong to the Cretaceous formation; and the discovery of the present form, though slightly aberrant from the type, is one more link which binds our tertiary beds to the upper secondary of Europe. The differences in this species are, that the internal edges of the septa are not united, and there are fewer cycles than the Mesozoic forms.

Smilotrochus vacuus, n.s. Corallum, very small, spear-shaped, very much compressed at the base and finely pointed, presenting at each side of the centre an elongated swollen tuberosity which tapers off slightly above, but is produced into a very finely pointed margin at each side of the base. Costæ corresponding to the septa, fine, straight, separated at the calicular margin, becoming fainter below, disappearing about the centre, and finally reappearing at the base. Calice shallow, narrowly elliptical, rounded and depressed at the ends. Septa in six systems of four cycla, but those of the 4th and 5th orders wanting in the two central systems, granular, not much exsert, rather thick, the three first nearly equal, not united at their inner edge, and the place of the columella represented by a conspicuous central vacuity. Alt., 5; maj. axis, 3; min., 1½ millim. Very rare.

Sub. Fam. Caryophyllinæ.

1st Group. Trochocyathaceæ (many circles of pali).

Genus Deltocyathus. *Mil. Ed. & H.*, 1848.

Corallum, simple, conical, free, no trace of adherence, calice nearly circular, and shallow, columella ending in a rounded mul-

tipartite surface. Septa straight, large, exsert, and granular, and the higher orders generally well developed. Pali highly developed, unequal, penultimate largest and turned towards antepenultimate, so as to form chevrons or deltas. Costæ *highly developed*, distinct to the base, with many granulations.

I separate these corals from *Caryophyllia* because that genus was erected for adherent simple corals with only rudimentary costæ, which were never tubercular, crested, or spinous. The Australian species identified with Caryophyllia all depart from that type, so that I consider a different genus is necessary for their reception. It will include the present species, and one to be described by me shortly in the Linn. Soc. N.S.W. Proceedings, and *Caryophyllia viola*, Duncan and Woods. It must be observed that adherence or non-adherence are held of themselves to be of generic value, and form the essential differences between *Smilotrochus* and *Desmophyllum;* the form of the base also is a distinguishing character between *Platytrochus* and *Ceratotrochus*. When Prof. Duncan described his *Caryophyllia viola* he had only very few specimens, and these, from his descriptions and from the state in which they left my hands, I conclude were worn and deprived of some of their characteristics. Since then I have paid great attention to this fossil, and have now before me twenty-six well preserved specimens, so that I am enabled to correct his diagnosis in some important respects, as will appear from the following details.

Deltocyathus viola (*Turbinolia viola*, nobis, MS., 1860; *Caryophyllia viola*, Duncan, *Ann. Nat. Hist.*, 1865). Corallum, in the form of a somewhat laterally compressed cone; the angle being about 50, and the sides very slightly convex towards the middle, and the apex obtuse. The calice is shallow and elliptical, the major and minor axis being as 7½ to 5½. The septa are somewhat delicate; the three first orders exsert and rounded, the primaries the longest, all having lateral spiny granules in radiate lines. There are four cycla in six systems; the first and second are equal in thickness, the first reaching the columella; the *second reaching about two-thirds of the way; the tertiaries, thinner and approaching one another so as to join the pali in front of the secondaries; the fourth and fifth orders are thin, with very wavy margins, and only reaching about a third of the distance from the margin.* Pali, thin rounded lobes in front of the *three first orders, and very granular. The primaries tall and thin, the tertiaries bending or inclining so as to meet or nearly* meet in front of the secondaries, which *thus exclude their pali. Secondary opposite pali often uniting in short bilobate papillæ right in the centre of the calice.* In worn specimens the pali seem like one rounded broad lobe in front of the secondaries only. Columella *thick, solid,* and ending in two or three neat rounded compact

lobes. Costæ visible to the base, rounded, *straight, sharp, and roughly granular;* in four cycla, and corresponding to the septa, primaries, and secondaries, arising from the base; tertiaries almost immediately above; fourth and fifth orders, a fourth of the height from the base. Intercostal grooves rather wider than costæ, and showing at the edge a very thin wall. Alt., 10 to 12; maj. diam., 7½ to 9; min., 5¼ to 7 millim. In young specimens (alt., 4 millim) the columella is not distinguishable, and the pali are rudimentary like twisted laminæ before the first three orders. The *Italics* indicate where my diagnosis differs from Prof. Duncan's. (*Plate II, fig.* 3.)

Deltocyathus excisus (*Sphenotrochus excisus*, Duncan, Quart. Jour. Geol. Soc., 1870, p. 298). Corallum, somewhat large, high, cuneiform, much compressed inferiorly and narrowed, base with a curved notch, the sides being prolonged into acute short points; summit broadly elliptical; costæ few, broad, flat, finely granular, persistent from edge of calice to the base, and regularly alternating with the septa; intercostal spaces regularly subspinously granular. Septa usually in six systems of three cycla, but specimens with one system aborted as in the figure not uncommon; primaries and secondaries equal, very much exsert, and ascending in high rounded crests above the edge of the calice, covered with short, stout spines; tertiaries projecting about half as much as the others, and reaching half way to the columella, all the septa very thick at their origin. Pali moderately broad and high, but not so high as the septa, to which they are united lower down to the 1st and 2nd cycle only. Columella, not distinguishable from the pali in the centre. Calicular fossa, shallow. Alt., 10; maj. axis of calice, 5½; min. axis, 4; height of exsert septa above edge, 2; length of base, 2 millim. Common. The type specimen of this species was sent to England by me in 1864 to Prof. Duncan; but it was unfortunately young and imperfect, and was more like a *Sphenotrochus* than a *Deltocyathus*, as there were only very faint indications of pali, and the columella was of a doubtful character. It was regarded as a *Sphenotrochus* by the learned Professor, who gave the following diagnosis—*Quart. Jour. Geol. Soc., loc. cit.* "*Sphenotrochus excisus*. The coral is much compressed, especially inferiorly, where two lateral processes give a notched or emarginate appearance to the base. Superiorly the relation of the long to the short axis is as 2 to 1. The coral is short and broad, the base is nearly as wide as the calice is long. The costæ are large and plain and are separated by well marked lines; the costæ of the appendices are the largest, they pass upwards to the calice, and are all more or less wavy, the centre widening out near the calicular margin. The calice is shallow and elliptical. The columella is not long, and from being joined to the primary and secondary septa by processes which are rounded above is

confused in appearance. The septa are in six systems of three cycles, they are wider at the wall than elsewhere and granular, and those of the third cycle are much smaller than the others. All the septa correspond to the depressions between the costæ. Alt., ¼ inch; tot., $\frac{3}{10}$ inch. Hamilton, Victoria." Prof. Duncan gives one admirable figure of the fossil, but as the specimen is young the septa and pali were not developed. I have figured an abnormal specimen with only five systems, owing to a deformity on the side of the corallum which is not shown in the figure. The septa also are more exsert in this instance than usual and the base narrower, but it is the same species. (*Plate I, fig.* 3*a*, *and plate II, fig.* 1.)

Family ASTRÆIDÆ. *Sub-family* EUSMILINÆ. *Division* TROCHOSMILIACEÆ.

Genus CONOSMILIA. *Duncan*, 1870.

Coral, simple, pedicellate, conical. Columella formed of one or more twisted laminæ which extend from the base upwards. Endotheca scantily developed. Septa apparently with simple margins, and variable in regard to the number of the primary.

This very remarkable genus was erected by Professor Duncan for some Australian Tertiary corals of very abnormal form. They are simple, with pellicular epitheca having a peculiar zigzag or "herring-bone" ornamentation, an essential twisted columella with endothecal dissepiments and plain septa, sometimes in six and sometimes in eight systems. These irregular septal arrangements occur in some genera of the Lower Greensand and Oolitic periods. The species I have to bring under notice has only two cycles in six systems.

CONOSMILIA BICYCLA, N.S. Coral, small, curved, slightly tapering, tall, pedicellate, base half the size of calice, costæ only traceable by the faint line which separates them, "herring-bone" pattern scarcely discernible. Columella large and strong, and is formed of one twisted lamella, and does not occupy much space. Septa arising between the costæ and are in six systems of two cycla; the primary reach the columella and are attached to it by processes, and are very wavy, uneven, and of equal thickness throughout. The secondary are very small, not reaching a fourth of the distance to the columella, curved and twisted. All are sparely studded with long spiniform granules. Endotheca sparely developed. Wall very thin, calice nearly circular. Alt., 12; diam. base, 2½; diam. calice, 3 millim. Rare.

The following is a synopsis of the species already known:—

Systems 8, cycles 3:

Pedicel large, costæ prominent and granular. *C. elegans.*

Pedicel small, costæ faint, calice elliptical. *C. anomala.*

Pedicel very small, costæ very faint-marked with prominent rings of growth. *C. lituolus.*

Systems 6, cycles 3:

Costæ very broad and flat, with wavy lines. *C. striata.*

Systems 6, cycles 2:

Costæ faint, coral curved and horn-shaped. *C. bicycla.*

The following is a list of all the known Australian Tertiary Corals corrected in accordance with the present paper:—

Conocyathus cyclocostatus. Tenison-Woods.
Conocyathus fenestratus. „
Trochocyathus meridionalis. Duncan.
„ *victoriæ.* „
Deltocyathus viola. T. Woods and Duncan.
„ *italicus.* M. Ed. and Haime.
„ *excisus.* Duncan.
Sphenotrochus variolaris. Tenison-Woods.
„ *australis.* Duncan.
Conotrochus McCoyi. „
„ *typus.* Sequenza.
Smilotrochus vacuus. Tenison-Woods.
Flabellum candeanum. M. Ed. and H.
„ *distinctum.* „
„ *victoriæ.* Duncan.
„ *gambierense.* „
„ *Duncani.* Tenison-Woods.
Placotrochus elongatus. Duncan.
„ *deltoideus.* „
Amphihelia incrustans. „
Heliastræa tasmaniensis. „
Thamnastræa sera. „
Palæoseris Woodsi. „
Cycloseris tenuis. „
Conosmilia elegans. „
„ *lituolus.* „
„ *anomala.* „
„ *striata.* „
„ *bicycla.* Tenison-Woods.
Balanophyllia campanalata. Duncan.
„ *seminuda.* „
„ *armata.* „
„ *tubuliformis.* „
„ *fragilis.* „
„ *australiensis.* „
„ *Selwyni.* „
„ *cylindrica* (variety) „
„ *Ulrichi* „
Dendrophyllia epithecata „
„ *Duncani.* Tenison-Woods.

The results of the observations contained in the foregoing paper are :—

1. That we have no *Caryophyllia* living or fossil in the Australian seas or rocks.

2. That we have three well marked and peculiar forms of *Deltocyathus*.

3. That we have two species of *Sphenotrochus*, one of which is still existing.

4. That we have two fossil analogues of our living *Conocyathus sulcatus*, which latter is supposed to be identical with a European Miocene form.

5. That we have a fossil form of the Cretaceous genus *Smilotrochus* in our Miocene rocks.

6. Also a new species of *Conosmilia* with only two cycles.

I may add also that, in a monograph I am preparing of our Australian living corals, I shall have occasion to describe two new species of *Deltocyathus*, one very similar to *D. viola*, and several species of *Paracyathus*, *Balanophyllia*, *Eupsammia*, *&c.*

Explanation of Plates.

Plate I.

Fig. 1.—*Placotrochus elegans.*
Fig. 1*a*.—Ditto, calice.
Fig. 2.—*Conocyathus cyclocostata.*
Fig. 2*a*.—Ditto, calice.
Fig. 3.—*Deltocyathus excisus.*
Fig. 3*a*.—Ditto, calice, with only five systems and distorted pali.

Plate II.

Fig. 1.—Normal calice of *Deltocyathus excisus.*
Fig. 2.—*Smilotrochus vacuus.*
Fig. 2*a*.—Ditto, calice.
Fig. 3.—Calice of *Deltocyathus viola.*
Fig. 4.—*Sphenotrochus variolaris.*
Fig. 4*a*.—Ditto, calice.
Fig. 4*b*.—Ditto, young calice.

Note.—The figure of *Conocyathus fenestratus* is unavoidably held over for a future paper.

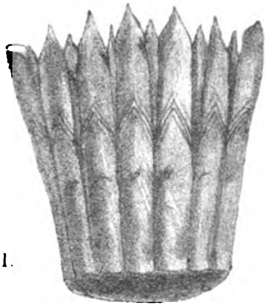

Fig. I.

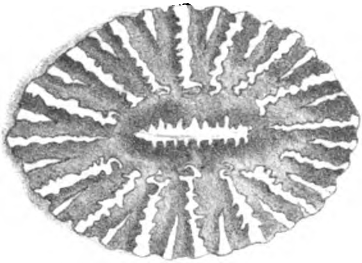

Fig. Ia

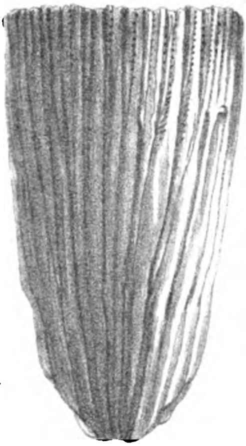

Fig. II.

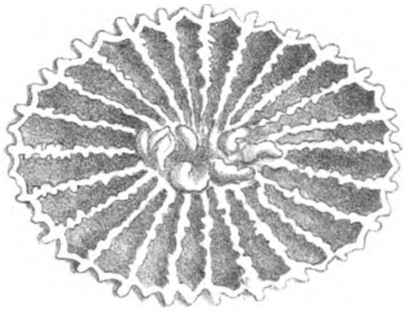

Fig. IIa

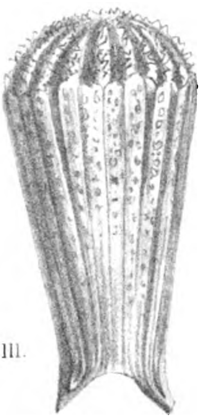

Fig. III.

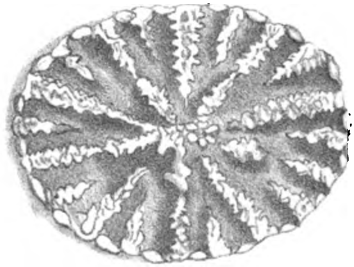

Fig. IIIa

TEN SON WOODS, DELT

S T LEIGH & Cº LITH SYDNEY

I. Placotrochus elegans
Ia Calice

III Deltocyathus excisus
IIIa Do Calice with only

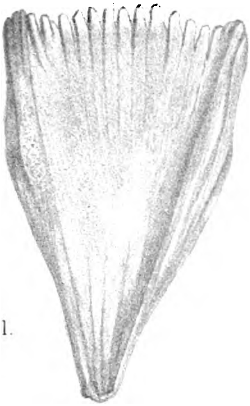

Fig. II.

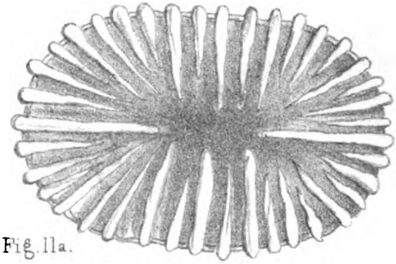

Fig. IIa.

Fig. IVa.

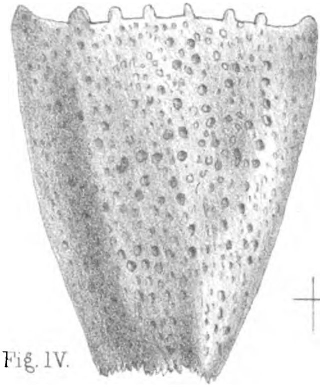

Fig. IV.

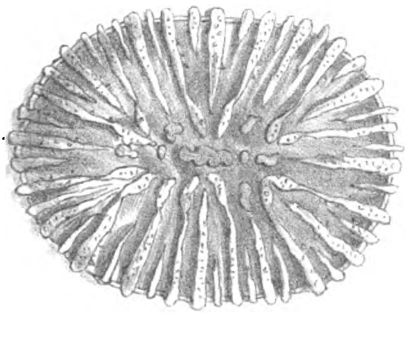

Fig. III

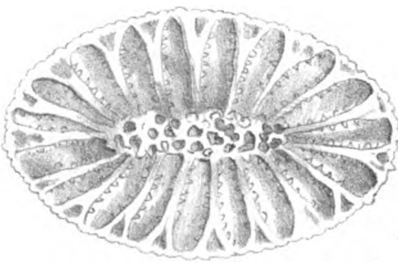

Fig. IVb.

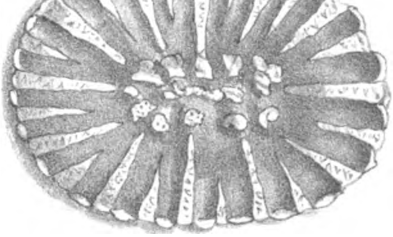

Fig. I

J. E. TENISON-WOODS, DELT.

S. T. LEIGH & Co. LITH. SYDNEY.

I. Normal Calice of D. excisus
II. Smilotrochus vacuus

IV. Sphenotrochus variolaris
IVa. Do. Do. Calice

On a new and remarkable Variable Star in the Constellation Ara.

By JOHN TEBBUTT, F.R.A.S., &c.

[*Read before the Royal Society of N.S.W., 5 December, 1877.*]

THE members of the Royal Society have doubtless observed a notice from me in the daily newspapers of the discovery of a new and remarkable variable star in the constellation Ara. My object now is to lay before the Society the detailed observations which have led to the discovery of the star's variable character. They will, I think, be interesting to the members, and at the same time show, as has been done before in the history of astronomical science, that a record is sometimes found to possess another and more important use than that for which it was originally intended. It will be remembered by the members of the old Philosophical Society that in October and November, 1862, I read before them two papers containing the results of my rough observations of the comet which was then visible in our southern sky. The papers were afterwards published in their Transactions for 1862–5. The observations of the comet were made with a ring-micrometer on my old refractor of $3\frac{1}{4}$ inches aperture and 48 inches focal length, the telescope itself being mounted on an ordinary tripod stand under the verandah of my present residence, and without divided circles of any kind. The time-keeper employed was a good common clock with seconds pendulum. The method which I adopted for determining the positions, and thus identifying the small stars compared with the comet, was the following:—After observing several transits of the comet and star of comparison across the ring, I compared the latter by means of the ring with some conspicuous star nearly on the same parallel of declination and visible to the naked eye. Where the stars differed considerably in declination and could not be embraced by the ring, I observed the transits across the field of view of the telescope. Sometimes I had to wait for an hour or more before such a bright star could be found to transit the field, the telescope of course remaining undisturbed in the interval. The bright star was then identified by a chart, and verified by observations made with a good sextant reading by a vernier to ten seconds of arc. Every precaution was taken in each case to ensure the correctness of the identification of the comparison stars, with what effect will best be seen from an examination of the comet observations published

in the pages of the "Royal Astronomical Society's Monthly Notices," and the "Astronomische Nachrichten." On some occasions a series of stars of the 6th and 7th magnitude were observed with the comparison stars, in order thereafter to set the identity of the latter beyond all doubt. Having now stated the general plan pursued by me for the identification of the comparison stars, I will proceed to explain its connection with the subject of the present paper.

The evening of October 4th, 1862, being beautifully clear, I obtained six observations of the comet with the ring. The first three comparisons were made with two stars designated in my journal as A and B. A was of the 7th magnitude and B of the 6½; the former preceded the comet in right ascension and the latter followed it. The fourth comparison was made with another star C of the 8th magnitude preceding the comet and B following it. The fifth comparison was made with A, and the sixth with C. A reduction of the transits in which A and B were both observed gave the following results for differences of right ascension of the two stars, B being east of A:—

		m. s.
1st comparison	B—A =	+ 6 37·84
2nd "	B—A =	+ 6 37·83
3rd "	B—A =	+ 6 38·58
	Mean =	+ 6 38·08

It was impossible to determine with accuracy the difference of north polar distance as B passed very near the centre of the ring, but it was estimated to be about 8′, B being south of A. Shortly after the completion of the six comparisons above mentioned a single comparison across the field of view was obtained of the comet, the star B, another star D of the 6½ magnitude, and a star of the 5th magnitude visible to the naked eye, which latter being the brighter of two stars about a degree apart, I at first took to be Sigma Aræ. This 5th magnitude star I will for convenience designate V. A reduction of this comparison gave the following results for difference of right ascension and north polar distance of the stars, V having passed through the centre of the ring and the field:—

	R.A. m. s.	N.P.D. ′
B—V =	— 57 8·36	— 18
D—V =	— 55 55·67	+ 25

B and D having crossed at a great distance from the centre of the field, their relative positions were determined with tolerable accuracy as follows:—

D—B, in R.A. = + 1 12·69 (m. s.) D—B, in N.P.D. = + 43 11 (′ ″)

I may state that the value adopted for the semi-diameter of the field of view was 26′ 19″. It was remarked this evening that a small round nebula appeared north of the star V, both of which objects could be embraced in the same field of view. The following evening, the 5th, was also very clear, and I compared B and another star E of the 6 or 6½ magnitude with the bright star V across the field of the telescope, with the following results :—

		m.	s.		′
1st comp....	B—V in R.A. =	— 57	5·36	B—V in N.P.D. =	— 15
2nd „	B—V „ „ =	— 57	1·85	B—V „ „ =	— 21
1st „	E—V „ „ =	— 12	16·51	E—V „ „ =	+ 24

In the first comparison V crossed very near the centre of the field, and in the second B passed very near it, but as both B and E crossed at a good distance from the centre in the first comparison their relative position was pretty well determined as follows :—

$$\text{E—B, in R.A.} = +\ 44^{\text{m}}\ 48^{\text{s}}{\cdot}85 \qquad \text{E—B, in N.P.D.} = +\ 38'\ 48''$$

It is remarked that the star E was "the following and brighter star of two about three minutes of arc apart, its companion being about the 7½ magnitude." On the evening of the 6th, which was also beautifully clear, I observed a transit of B and V, which latter according to a remark of this date was "a degree or two south of Theta Scorpii," and was still regarded by me as Sigma Aræ. This comparison was made with the ring-micrometer, and as both objects crossed it very far from its centre the result for north polar distance was satisfactory. The following is the result :—

$$\text{B—V, in R.A.} = -\ 57^{\text{m}}.\ 7^{\text{s}}{\cdot}11 \qquad \text{B—V, in N.P.D.} = -\ 16'\ 10''$$

On this evening there is a rough sketch of the comet and stars included in the same field of view with it. B is embraced in this sketch. On the evening of the 9th I for the first time observed with the sextant the star V, which I had erroneously supposed to be Sigma Aræ, but which, as my remarks for that date state, "was really about a degree north-east of that star and somewhat more conspicuous to the naked eye." I give the sextant observations as recorded, with the exception that the clock times are corrected to Windsor mean time :—

h. m.			°	′	″	
At 7 6¼	.... Index error... ...	—	0	1	0	
„ 7 9¼	Read-off distance from Theta Scorpii ...		2	27	40	
„ 7 12¼	„ „ „ „ Theta Scorpii ...		2	30	0	(better).
„ 7 19¼	„ „ „ „ Altair		61	49	50	
„ 7 25¼	„ „ „ „ Antares............		23	36	40	
„ 7 32¼	„ „ „ „ Epsilon Sagittarii		14	2	40	
„ 7 35¼	.... Index error	—	0	1	0	

Immediately afterwards a single comparison of B and V across the ring was observed with the following result, which was likewise good for the determination of the difference of north polar distance:—

$$\text{B—V, in R.A.} = -\ 57^{m}\ 2^{s}{\cdot}85 \qquad \text{B—V, in N.P.D.} = -\ 17'\ 36''$$

Adopting the sextant distances from Altair and Antares, taking the apparent positions of these stars for October 9th, 1862, from the "Nautical Almanac," and employing mean refraction for temperature 50°, and pressure 29·6 in. in the reduction, I get the following for the apparent place of the star V.:—

$$\text{App. R.A.} = 17^{h}\ 29^{m}\ 6^{s}{\cdot}60 \qquad \text{App. N.P.D.} = 135^{\circ}\ 23'\ 42''{\cdot}8$$

which reduced to the mean place for 1862·0 with the help of the independent constants on page 331 of the Almanac becomes—

$$\text{R.A.} = 17^{h}\ 29^{m}\ 2^{s}{\cdot}51 \qquad \text{N.P.D} = 135^{\circ}\ 23'\ 33''{\cdot}8$$

Employing now the two sextant distances from Theta Scorpii and Epsilon Sagittarii as a test, I find they both establish within a few seconds of arc the correctness of the position deduced from the measurements from Altair and Antares; so there cannot be the slightest doubt that the position of the star V was fixed within a minute of arc on the evening of October 9th, 1862. If now we adopt the mean of the differences of apparent right ascension and north polar distance of B and V as determined on the 6th and 9th with the ring, we get the mean position of B for 1862·0 as follows:—

	h. m. s.		° ′ ″
App. R.A. of V	=17 29 6·6	App. N.P.D. of V	=135 23 43
Diff. of App. R.A. of stars	= — 57 5·0	Diff. of App. N.P.D. of stars	= — 16 53
Reduction of B to 1862·0	= — 0 3·6	....	— 0 12
Mean R.A. of B for 1862·0	=16 31 58·0	Mean N.P.D. of B for 1862·0	=135 6 38

Again, adopting 6m. 38·1s. W. and 8′ N. as the position of A with reference to B, we get for the position of A = R.A. = 16h. 25m. 19·9s., N.P.D. = 134° 58′ 38″. It will be at once seen that the stars A and B are identical with Nos. 5754 and 5799 respectively of the Brisbane Catalogue, whose mean places brought up to 1862·0 by means of the precession in the catalogue are,—

		h. m. s.		° ′ ″
No. 5754	R.A.	= 16 25 11·07	N.P.D.	= 134 56·38
„ 5799	„	= 16 31 49·07	„	= 135 5·33

It must be understood that the discrepancies between the observed and tabular right ascensions are in a great measure the combined result of errors in the sextant observations of V, and the imperfect going of the clock for so long an interval as fifty-

seven minutes. Assuming now the observed position of E with reference to B as the approximate difference of the stars' mean places, we get for the mean place of E for 1862·0 thus :—

	h. m. s.		° ′ ″
Mean R.A. of B 1862·0 =	16 31 58·0	Mean N.P.D. of B 1862·0 =	135 6 38
Diff. R.A. of stars =	+ 44 48·9	Diff. N.P.D. of stars =	+ 38 48
Mean R.A. of E 1862·0 =	17 16 46·9	Mean N.P.D. of E 1862·0 =	135 45 26

which agrees pretty well with the position of Lacaille 7267, as brought up from that catalogue by means of precession alone as follows :—

	h. m. s.		° ′ ″
R.A. =	17 16 37·5	N.P.D. =	135 43 37.

We have thus cumulative evidence of the accuracy of the determination with the sextant of the position of V. On consulting the Catalogue of the British Association, and especially the very exhaustive one of Lacaille, I was much surprised to find that this star V, being one so conspicuous to the naked eye and certainly not less than the 5th magnitude, had not been recorded. After the publication of my comet observations in the beginning of 1863, I thought no more of the subject till a few days ago. While engaged in searching for the most accurate determinations of the places of the comparison stars observed with the Comet III, 1862, with a view to the ultimate publication of my collected astronomical results, I in due course came to my old work for October 4th, 1862. Since the year 1862, my library had been enriched by many presents from the astronomical institutions of Europe, America, and the Colonies, and among these volumes are to be found several valuable star-catalogues. The excellent U. S. Naval Observatory Catalogue of 10,658 stars, and the Transit and Mural Circle Zones of that establishment, furnished me with many of the places of the stars observed with Comet III, 1862; but neither in these nor in the valuable Sydney and Melbourne catalogues could I find the star designated V. My curiosity was aroused, and accordingly on the 13th instant I turned the 4½-inch equatorial to the spot occupied by the star in question, when to my surprise there was no object to be seen in the field of view except stars of the 10th magnitude downwards. It immediately occurred to me that the star V was a variable one of a remarkable class, and had diminished since 1862 so as to be hardly visible in the telescope. Adopting the mean place of V for 1862·0 as before derived in this paper, and + 4·415s. and + 2·69″ as its annual precession in R.A. and N.P.D., I obtained the mean place for 1878·0 as follows,—R.A. = 17h. 30m. 13·15s., N.P.D. = 135° 24′ 16·8″. A careful examination of this position on the evenings of the 13th, 14th, and 17th instant showed that the only star in or very near it was a

very faint one of the 11th magnitude. With the hour-circle of the equatorial clamped, I observed the transit of this faint star, Theta Scorpii, and Sigma Aræ, the differences of north polar distance being inferred from the readings of the declination circle. The following is the mean result of three comparisons for the position of the faint star:—R.A. = 17h. 30m. 21s., N.P.D. = 135° 23′. Owing to the bright moonlight and the rather low altitude the faint star was observed with much difficulty. The place thus determined agrees pretty well with that of V obtained from the sextant observations of October 9th, 1862. Taking therefore into account all the circumstances recorded in this paper, I am forced to the conclusion that the faint star observed on the 13th, 14th, and 17th instant is identical with the bright star V of October, 1862. There are, however, several faint stars within a few minutes of arc of its position, but considering that the place of the star just given cannot be more than a minute of arc in error, I think none of these faint stars can have a claim to be regarded as identical with V. Now that the moonlight is so strong, in conjunction with the low altitude of the stars, it is extremely difficult to observe even with a dark field; but I hope, as soon as the moon's absence will permit, to fix accurately the position of all the small stars in the field of view adopting the variable as the centre. I have communicated the discovery to the Government Astronomers at Sydney and Melbourne, with the request that they will confirm my present estimate of the magnitude of the variable. Such independent observations will be of value should another outburst of the star's light take place in future years. I may state that the nebula seen in the same field of view with the star on October 4th, 1862, is doubtless No. 3690 of Sir J. Herschel's Cape Catalogue for 1830. In conclusion, I think the star bids fair to occupy an important place among the stars of its class. Sir John Herschel, in his *Outlines of Astronomy*, edition 1851, p. 563, says:—"It is worthy of especial notice, that all the stars of this kind on record, of which the places are distinctly indicated, have occurred, *without exception*, in or close upon the borders of the Milky Way, and that only within the following semi-circle, the preceding having offered no example of the kind." A brief inspection will show that the present variable offers another example in proof of that eminent astronomer's statement.

The Observatory, Windsor,
November 22nd, 1877.

On a Dental peculiarity of the Lepidosteidæ.

By W. J. Barkas, L.R.C.P.L., M.R.C.S.E.

[*Read before the Royal Society of N.S.W.*, 5 *December*, 1877.]

I am induced to make some remarks on this family of fossil fishes, as I have noticed in the twentieth volume of the Quarterly Journal of the Geological Society of England a brief notice of some fossil fishes obtained from the carboniferous strata of Wianamatta, Cockatoo Island, and Newcastle, that the Rev. W. B. Clarke had forwarded to England for examination. The author of the paper stated, "that after the closest scrutiny I have been unable to detect any difference between this fish and the genus Palæoniscus, save only in the position of the dorsal fin, which is more advanced than in any species of Palæoniscus with which I am acquainted. It is placed at nearly the centre of the back, as in the genus Pholidophorus, instead of more or less behind this point, as in the Palæonisci. The tail (if the detached fragment belongs as is stated to the specimen) is a true heterocercal form undistinguishable from that of Palæoniscus. The position of the dorsal fin, although not a feature of generic importance unassociated with other discrepancies, gives nevertheless a specific character to the fish, and I propose to name it *Palæoniscus antipodeus*. The result, then, of the examination of these specimens (in so far as materials so imperfect and scanty can be said to lead to any result), is the supposition that they give indications of four genera of fossil fishes—one allied to Pygopterus (*Urosthenes Dana*), one allied to Acrolepis (*Myriolepis*), one allied to Platysomus (*Cleithrolepis*), one indistinguishable from Palæoniscus, Agassiz." In the above extract there are three known genera of the Lepidosteidæ named:—Palæoniscus, Pygopterus, and Acrolepis, so if Urosthenes and Myriolepis are truly allies of Pygopterus and Acrolepis respectively, we have, then, three genera, Palæoniscus, Urosthenes, and Myriolepis, representing this family that have been obtained from the coal strata of the Colony of New South Wales. Unfortunately I have never seen these specimens, nor have I been able to meet with any detailed account of them. It will be noticed that in the abstract I have quoted above, there is no description of Urosthenes nor of Myriolepis, and the only details of the character of the Palæoniscus mentioned are the position of the dorsal fin and the heterocercal nature of the tail. Considering

that the author of the paper speaks with a great deal of authority, we will take it for granted that he was well enough acquainted with the external characteristics of Palæoniscus, Pygopterus, and Acrolepis, to be able to determine that these fossil remains belonged to one or other of these genera or were close allies.

Up till the period of the publication of Professor Huxley's classification of fossil fishes there was great difficulty in arranging them, not because there was no master mind to reduce the chaos, but because the remains of the fishes were either too scanty or too securely hidden in private cabinets. Even Huxley's synopsis is not without flaw; still it is the best at present before palæontologists. He divided the class of fossil fishes into Plagiostomes and Ganoids. The order Ganoidei he further subdivided into families, of which the first on the list is the Lepidosteidæ. This family he again bisected into the Lepidosteini and the Lepidostini, the former being distinguished by having the maxilla formed of more than one bone, and its branchiostegal rays few and unenamelled; the latter by the maxilla consisting of one bone and having numerous enamelled branchiostegal rays, the anterior rays possessing the form of broad plates. The general characters of the Lepidosteidæ are:—a heterocercal tail, rhomboidal scales, branchiostegal rays, a pre-operculum, an inter-operculum, and non-lobate paired fins. Of the fossil fishes bearing these general distinguishing points, the following have been named:—Palæoniscus, Pygopterus, Acrolepis, Gyrolepis, Cycloptychius, Urosthenes, Myriolepis, Lepidotus, Aspidorhynchus, Oxygnathus, Semionotus, Dapedius, Æchmodus, Tetragonolepis, Caturus, Ditaxiodus, Pomognathus, Saurichthys; there may be others, but these are all that I am at present able to recall or learn from others. Some of these were formerly classed by Agassiz and Professor Owen as sauroids, viz., Saurichthys, Pygopterus, Acrolepis, Caturus, Ditaxiodus, and Pomognathus. With the first five of the above list of genera I am best acquainted, as in preparing my papers on the "Microscopical Structure of Fossil Teeth from the Northumberland True Coal Measures," for the Monthly Review of Dental Surgery, I had to study them very closely. My attention was drawn to the teeth of these five genera by a paper published in the third volume of the "Transactions of the Northumberland and Durham Natural History Society," in which Messrs. Hancock and Atthey pointed out that the teeth of Palæoniscus, Pygopterus, Acrolepis, Gyrolepis, and Cycloptychius, were tipped in a very peculiar fashion by a piece of enamel or ganoine. On examining them for myself I found that they were so constituted, and I was curious to learn whether this was a characteristic present in all the genera pertaining to the Lepidosteidæ. No one appears to have inferred that the teeth of all the genera of this family might be thus tipped with

enamel; I consequently drew the attention of Wm. Davies, Esq., of the British Museum, to the probability of such being the case, and asked him to examine the specimens under his supervision. In due time I had the pleasure of receiving the following information:—"The teeth of Aspidorhynchus and Oxygnathus are undoubtedly tipped with enamel, of Semionotus there is no specimen which shows teeth in the collection. The marginal teeth of Lepidotus and Dapedius are also tipped with enamel, but are not so sharply pointed as the teeth of Pygopterus, &c. I cannot say with certainty, from examples in the collection, that the teeth of Æchmodus and Tetragonolepis are thus tipped, but that the summits are covered with enamel is certain." From the writings of Professors Owen and Agassiz, I learn that Saurichthys is also tipped with enamel. Of the eighteen genera that I have named as pertaining to the Lepidosteidæ, we find that ten are certainly tipped; two are enamelled on the summit, but it has not been ascertained whether the ganoine is arranged as a tip; six of which the teeth are not known, and in these are included the Australian Urosthenes and Myriolepis. I have tried to obtain specimens of the last six genera that showed teeth, but have been unsuccessful, and I cannot learn from others that the teeth have ever been seen; however, twelve out of the eighteen are known to have enamel on the summits of their teeth; it is, therefore, probable that all the other members of the family are so characterized, and I am strongly of the impression that any fish at present placed among the Lepidosteidæ that has not its teeth tipped has been wrongly classified, and pertains to some other family of Ganoids.*

Having pointed out how general this peculiarity is in the known Lepidosteidæ, I shall now draw attention more particularly to the teeth themselves, and I shall take the teeth of Palæoniscus and Pygopterus as typical examples, not only because they are truly typical, but also because Palæoniscus and an ally of Pygopterus (Urosthenes) are said to be present in the coal-bearing strata of New South Wales. The teeth are arranged along the alveolar borders of the maxilla and mandible in two rows which

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* By the November mail I received a number of recent papers by Professor Traquair on fossil fishes, and I notice that he has founded some new genera; that are close allies of Palæoniscus and Pygopterus, viz., Cheirolepis, Elonichthys, Gonatodus, and Nematoptychius. The last named he mentions as having tipped teeth, but he either is not acquainted with the structure of the teeth of the first three genera, or he has forgotten to detail this peculiarity if present.

Since my paper was written, I have recalled to my memory another fossil fish belonging to this family, viz., Amblypterus, but whether its teeth are tipped I know not.

Among fishes that are now in existence, there are only two that to my knowledge possess tipped teeth, and they are Lepidosteus and Polypterus.

run parallel with the long axis of the jaw and with each other. The internal row of teeth are large (comparatively speaking) and placed at distinct intervals of about equal distance. The outer row is formed of a great number of very minute teeth (in some species they are almost invisible to the naked eye), generally much crowded together, and often very irregular in their order; they are so numerous that the usual expression regarding them is that they are "*en brosse.*" Both the laniary and minute teeth are conical, with very sharp apices, the latter being generally straight but occasionally curved; the former are, in the two genera I have taken as typical, always curved in a direction usually inwards but often with a tendency forwards. The apices of these teeth are tipped with a thick "cap" of enamel, which is smooth and glistening on its external surface. On making a vertical section of one of these teeth, the peculiarity of the arrangement of the enamel is shown more perfectly. The tooth is composed of dentine enclosing a pulp cavity; as the dentine approaches the apex it rapidly attenuates to a sharp point, and upon this is fitted the "cap" of enamel, or ganoine as fish enamel is usually termed, which is also acutely pointed. The tip of ganoine, therefore, appears like an inverted V closely adjusted to the aciculated apex of the dentine. The structure of this "tip" I detailed and figured in chapter XIV of my series of papers on the structure of fossil teeth, when I was speaking of Acrolepis, and I here give it *in extenso.* "The enamel or ganoine tip is composed of a clear, perfectly transparent homogeneous tissue, in which ramify numerous tubules which are continuations of the tubules that have arisen from the pulp cavity and pursued their course through the dentine that intervenes between that cavity and the tip. The course of the tubules when they have entered the enamel tip tends to be parallel to the long axis of the tooth, those in the centre being quite parallel. As the tubules proceed into the enamel they become finer and finer, and ultimately disappear, very few of them reaching the periphery apparently; they do not, however, terminate in a boundary as they do in the dentine. Here again, I do not doubt that the tubules do reach the external surface, but it is impossible to trace them on account of their minuteness and the clearness of the tissue in which they ramify. Those tubules that are visible are rendered strikingly so by the dark carbonaceous matter contained in their interior contrasting with the clear tissue in which they are imbedded. In fig. LXVII the minute structure of the tip is well portrayed; its form, however, has been somewhat destroyed in making the section, the extreme tip having been rubbed away; it should be acutely pointed. I have added dotted lines to show the extent to which the enamel is wanting."

Discussion.

Mr. MacDonnell asked if the paper was written upon a fish which the writer had not seen.

Professor Liversidge said Mr. Barkas had not seen the particular specimen referred to; but he had devoted a considerable amount of attention to the subject of fossil fishes, and from the descriptions given of it, Mr. Barkas was inclined to think that it had been put in the wrong class. Mr. Barkas's views were, of course, open to discussion, and the discussion of systems of classification did good.

[Mr. MacDonnell has evidently quite mistaken the drift of this paper. In writing it my object was to point out that the majority of the genera in the family Lepidosteidæ, the teeth of which were known, had the teeth tipped in a peculiar manner with enamel, which fact consequently led me to the inference that all the other supposed genera and species of that family that had not tipped teeth probably pertained to some other family than the Lepidosteidæ. I referred to no particular fish, but took Mr. Clarke's specimens—being Australian—as a groundwork upon which to found my paper. Of course, if these Australian specimens have *not* tipped teeth, I, as Professor Liverside said, would certainly doubt their classification; for every example of Palæoniscus, Pygopterus, and Acrolepis that I have examined, and the number of them is large, *had* teeth tipped with enamel. I have never seen the New South Wales specimens referred to, as Mr. Clarke informed me that none of them showed any teeth. Their classification is, therefore, uncertain, and future discoveries may enable us to decide as to the nature of their teeth.]

Notice of a New Fossil Extinct Species of Kangaroo, *Sthenurus minor* (Owen).

[Supplemental to the notice of the new fossil bird, *Dromornis Australis* (Owen). By the Rev. W. B. Clarke, M.A., F.R.S., &c.]

[*Read before the Royal Society of N.S.W.*, 5 *December*, 1877.]

At the close of the paper on *Dromornis*, I mentioned that I had received from Mr. Lowe, of Goree, a portion of a skull of an extinct marsupial, which I was informed came from a lead in the neighbourhood of the "pelvis" of the new fossil bird.

I sent them in the same box to Professor Owen, who has reported on the skull, in the Proceedings of the Zoological Society of London, of April 17, 1877.

As that report may not fall in the way of some members of this Society, it may be useful to make the existence of the new Marsupial known to them by quotations from Professor Owen's remarks, in order to assist in extending information on the Marsupials of Australia.

The report is headed, "On a new species of *Sthenurus*, with remarks on the relation of the genus to *Dorcopsis*, Müller. By Professor Owen, C.B., F.R.S., F.Z.S., &c." (Plates XXXVII and XXXVIII.)

The author says:—"The present species of extinct kangaroo is founded on a fossil fragment of a skull, including the molar series of both sides of the upper jaw, with the intervening bony plate.

"The reference to the genus *Sthenurus*, in Professor Garrod's excellent memoir on *Dorcopsis luctuosus* (Proceedings Zoological Society, 1876), encourages me to think the following notes may not be unacceptable to the Society, which has occasionally admitted illustrations of extinct animals into its publications. The fossil was found in a 'rocky alluvial deposit,' in the shaft of a gold-lead in the County of Phillip,* New South Wales, Australia, and was transmitted to me by the Rev. W. B. Clarke, M.A., F.R.S., the veteran geologist of New South Wales. The fossil is in a massive petrified condition.

"The smallest species of the extinct genus, known at the date of my eighth paper on the "Fossil Mammals of Australia," (P. T., 1874), was the type of one (*Sthenurus atlas*), in which the

* I have recently (November 21, 1877) been informed by Mr. Lowe that the skull came from the Talbragar country. In that district other marsupial relics have been found. I have left the statement in the text with this correction, as the only way of explaining in this note the change of *habitat*, and in ustice to Professor Owen, who received the first statement through me.

fore and aft extent of the crown of the upper premolar is nine lines, that of the entire permanent series of upper molars being 2 inches 11 lines. A second species of *Sthenurus (S. brehus)* has the upper premolar 10 lines in fore and aft extent; that of the permanent series of upper molars is three inches four lines. In *Osphranter rufus* this series is two inches three lines, reduced by loss of the premolar to two inches (as in Trans. Zool. Soc., vol. IX., pl. 74), and these dimensions are not exceeded in *Macropus major*. The extinct kangaroo represented by the subject of pl. XXXVII somewhat exceeded the above largest known existing species. The fragment of skull is a little larger than the corresponding part of a full grown *Macropus major*, with the last molar in place and use and the premolar shed; it consists of both maxillaries with their respective (right and left) molar series, the intervening bony plate and a portion of the right orbit, and zygoma with the descending masseteric process. The dentition is in an instructive phase.

"In 1874, M. d'Albertis described and figured a small existing kind of Kangaroo, under the name of *Halmaturus luctuosus*, obtained in the south-east of New Guinea, with a pre-molar more trenchant than in *Sthenurus*, and with the proportions of the tooth differing in the opposite extremes of fore and aft extent, and in greater degree than in *Halmaturus*, from those in the premolar of *Sthenurus*.

"This rare Kangaroo was deposited in the Zoological Gardens, and on its death, in November, 1874, was anatomised by the accomplished pro-sector, A. H. Garrod, B.A., by whom the skull and teeth are well described and figured. Professor Garrod refers the specimen to the same genus as the *Dorcopsis muelleri* of Schlegel."

Besides some other differences, "in *Sthenurus* the transverse thickness of the pre-molar decreases as the crown extends forward; in *Dorcopsis* the transverse thickness is uniform, or is maintained to very near both ends of the crown.

"I have not found an upper canine in a *Sthenurus* of any age.

"In all these characters" (some here omitted) "*Sthenurus* deviates from the Halmaturine, Dorcopsine, and Hypsiprymnine types, and approaches that of the great Kangaroos represented by Macropus proper, Osphranter, and Borigale. (P.T. 1874, pl. xx.)

"What evidence, it may be asked, does the skeleton afford of the affinities of the huge Kangaroos of the genus *Sthenurus?* I am able only to adduce those yielded by the skull. The time may come when, in some Australian cavern, a greater proportion of the enduring framework may be recovered in connection with the skull and dentition of one and the same individual. Fortunately the cranial characters at present known are instructive ones, are well shown in the portion of the skull of the smaller

species under description, and the more welcome as repeating those previously given by a corresponding portion of a skull of *Sthenurus brehus*. (P. T. 1874, vol. xxviii.) The first of these characters is the integrity of the bony plate. In *Dorcopsis* (P.Z.S. 1875, pl. vii.), as in the *Hypsoprymninæ*, and as in most of the smaller Kangaroos which have been grouped under the less definite genera *Halmaturus*, *Petrogale*, *Lagorchestes* the bony palate *shows two or more large vacuities*. In *Dendrolagus* the palate is entire, as in *Macropus* and *Sthenurus*. The masseteric process is short in *Dorcopsis*, as in the Hipsiprymnines ; it is long in *Sthenurus*, as in *Macropus*."

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After noticing a mistake of F. Cuvier, as to the generic character of *Macropus*, the author continues :—

"Later investigations of the fossil marsupials of Australia have led to the interesting result, that the developmental condition which F. Cuvier believed to differentiate the larger Kangaroos of the genus *Macropus* from the smaller kinds referred to *Halmaturus* and *Hypsiprymnus* does actually differentiate the huge extinct herbivorous marsupials of the genera *Nototherium* and *Diprotodon* from the *Macropodidæ*, which we know to have been represented by species much exceeding in size the existing Kangaroos. Moreover, the large extinct Kangaroos, even in the partial degree in which we have already come to know them, manifest much better grounds for generic or subgeneric distribution than do any of the existing forms. And such extinct genera, represented as they are by species larger than the existing kinds, manifest in a highly interesting and instructive way an approximation to the Notothere and Diprotodons.

"*Macropus*, *Sthenurus*, *Procoptodon* exemplify stages of transition to the exclusively vegetarian character of the molar series exemplified by *Diprotodon*. The genera *Halmaturus*, *Dorcopsis*, *Dendrolagus*, *Hypsiprymnus* exemplify so many stages in the modification of the teeth for a mixed diet, which, in the Diprotodont series of Marsupialia, culminated carnivorously in *Thylacoleo*. Here the upper anterior incisors acquired their largest proportional size, with the change of the trenchant for the piercing or laniary type. The single lower pair of incisors underwent the same modifications. The conversion of the premolar, in size and shape, to a carnassial tooth, and the reduction of the molars in numbers and size to the tubercular condition of the feline molar, are exemplified in *Thylacoleo*, with corresponding figures of our Cave-Lion and Cave-Hyæna, in plate VI of my 'Researches on the Fossil Mammals of Australia.' In this work a preliminary chapter is devoted to the extinct Marsupials of England, in which it is shown that at the oolitic period our Marsupials had also diverged, by the modifications of the fundamental type, into

species exemplifying the 'polyprotodont' and the 'diprotodont' sub-orders—and that, in the formal or adaptive characters of the teeth, species diverged from the common carnivorous or insectivorous types in *Stylodon* and *Thylacotherium*, to the vegetarian type in *Bolodon* and *Stereognathus* in one direction, and to the carnivorous type exemplified by *Triconodon* and *Plagiaulax* in the opposite route."

In reproducing the valuable matter contained in the foregoing extracts, much of the minute critical comparison of the teeth of the various species has been omitted, the chief material quoted being of a more popular character than the details, and yet sufficiently instructive towards the encouragement of Australian explorers in the discovery of the extinct creatures whose remains have not yet reached their full investigation.

May I be pardoned for suggesting that, however necessary it may be to the progress of the present occupants of the prairie lands of Australia to keep within bounds the increase of Marsupials, which once were the support of a race nearly extinct, yet in the extermination that has now received the sanction of law in some of our Colonies, and which will be carried out without compunction when the interest of the squatter requires it, it is not improbable that some species still undistinguished by the scientific and unscientific alike will be included in the slaughter, and ere long Kangaroos may be creatures of the past, as well as the human tribes who are fast dying out.

It is possible, therefore, that Palæontology itself may be a sufferer in the long run. Thirty years since, Professor Owen lamented the want of skeletons of existing Marsupials, in order to study effectually the species that are extinct. Such may still be a source of difficulty in the researches of comparative anatomists, and as new extinct species will probably be discovered, it would be well if those who are making a full end of the *Macropidæ* would save at least some of the hitherto unnoticed species for investigation. But whether or not this consideration has influence, there is a great probability that if the gold-diggers and other persons referred to in the paper on *Dromornis* would make it a conscientious act to carefully preserve all relics of extinct creatures found in the course of their excavations, many new species, as well as those of *Dromornis* and *Sthenurus*, may be obtained for the service of Palæontologists, and towards the progress of general knowledge in the community.

Notes on some recent Barometric Disturbances.

By H. C. Russell, B.A., F.R.A.S., Government Astronomer.

[*Read before the Royal Society of N.S.W.*, 5 *December*, 1877.]

Some of the recent Barometric Disturbances, recorded by the self-registering barograph in the Observatory, are so remarkable that I think a few notes about them should be placed on record for reference; at the same time they will doubtless be interesting to the members present this evening.

The remarkable changes in atmospheric pressure during hurricanes are well known. Fitz Roy stated that a fall in Europe of one-tenth of an inch per hour presaged a storm. In the tropics, where the usual oscillations of the barometer are much *smaller* than in Europe, a similar fall would of course indicate a correspondingly greater disturbance. I have, therefore, for the sake of comparison, taken out from various records the average results for twenty hurricanes.

From these the average hourly fall as the hurricane comes on is 0·147 in.; the average period over which the fall extends is 10 hours, but of course the times of falling barometer vary very much—from 3 to 18 hours. The average total fall in a hurricane is 1·488 in., and the greatest and most rapid fall which I find recorded is that in the hurricane of May 21st, 1833, when the ship "Duke of York" was carried a great distance inland at the river Hoogley and wrecked. The river rose 12 feet perpendicularly, and 50,000 people were drowned. At 8 a.m. on that day the barometer read 29·09 in., and by 11·30 a.m. it read 26·50 in., or a fall of 2·59 in. in 2½ hours.

The first of the Sydney self-registering barograph records which I would like to bring under your notice is that for 16th November, 1877. The afternoon of that day was very cloudy, and so dark that the gas had to be lit in the office at 4 p.m., where, had the day been fine, it would not have been required until 7 p.m. Thunder and lightning were observed in several directions, but no defined storm took place. The barometer, however, began to rise rapidly at 4 p.m., and rose 0·080 in. in 20 minutes, when a sudden fall set in, in the most remarkable manner it has ever been my lot to witness, and in 24 minutes the barometer fell 0·175 in. —the latter half of the fall being much more rapid than the first, in fact quite as rapid as the rise which immediately set in at the rate of 0·130 in. in 8 minutes; now the fall is at the rate of 0·437 in. per hour, and the rise at the rate of 1·350 in. per hour. During the time these changes were being recorded, the anemometer recorded a change in the direction of wind right round the

compass, but there was nothing else except the darkness remarkable. From this time (5 p.m.) the barometer was unsteady, but not remarkably so until 7·20 p.m., when another remarkable change is recorded—the barometer fell 0·115 in. in 6 minutes, and rose 0·075 in. in the following 5 minutes; this fall is at the rate of 1·150 in. per hour, and the rise at the rate of 0·750 in. per hour. Again, there was a sudden change in the direction of the wind from S.S.E. to E.S.E. but nothing else to remark; the clouds being still very dark, but apparently passing away.

From 4 to 7·30 p.m. of the 21st November we have another remarkable curve during the passage of a heavy thunderstorm, and it illustrates very well one peculiarity of these storms to which I wished to draw your attention. It is that the curve *rises*, showing an *increase* of pressure as the storm approaches, and falls as the storm passes. Now, we are in the habit of speaking of *heavy clouds*, because they look massive and heavy; but we well know that as masses of vapour they are lighter than the air, and even when in such a condensed form that they are heavier, and therefore *falling*, the pressure must of course be distributed, because the falling motion is comparatively slow, and cannot act locally. It is well known also, from actual experience, that passing rain-clouds are lighter than the surrounding air. How then can we account for the increase of pressure which is so clearly shown here, and is a constant phenomenon of our thunderstorms? I think, in this way: The thunder-cloud is a storm mass, travelling by its own velocity (which is very considerable) *through* the air; and, in so moving, the air in front of it must get compressed as it gives way—and the effect is too rapid to be entirely dissipated by distribution—and it acts locally; but, if this is so, such a moving mass must cause a partial vacuum, or loss of pressure, in its rear; and such we find to be in fact the case, as the fall after the passage of these impulses is greater than the rise which they produce. These phenomena are quite familiar in the passage of a vessel through the water; but I am not aware that they have been before made evident in the passage of a storm through the air.

The next barometer curve which I have to bring under your notice is however in several respects the most remarkable I have ever seen. You have probably read in the daily papers accounts of a fearful storm in the Western Districts on the 27th November, 1877. At Grenfell the damage done to the houses in the town was very great, but I will not detain you with an account of this. I only wish to say that the morning was very sultry, and soon after noon heavy electrical clouds began to gather in the N.W., and at 5 p.m. the tempest broke upon the town with a deluge of rain and hail. On the same afternoon a terrific storm passed over Cowra, but unfortunately the time is not given. We

next hear of the storm at Carcoar after a fierce hot wind which had been blowing all the morning; but again the writer has omitted to give the time at which the storm began, and the account for scientific purposes is of very little value. It is next reported at Bathurst, and five cows were killed in the open field—(no time is given). During the afternoon at Sydney several storms passed; at 3 p.m., one passed north of the city, probably down the valley of the Hawkesbury; but the air did not clear, and clouds began to get very heavy to south-west, and the storm gradually approached, with almost incessant lightning, which was for the great part down-strokes; at 7·30 p.m. the storm was passing over Sydney, and then the down-strokes were very few, but the discharges between the clouds very frequent. Struck with the long interval between the flash and the reports, I took out a stop-watch and found that one flash nearly overhead, and so bright that it appeared to be on the under surface of the clouds, was 8^s before the report; several were 10^s, others 12^s, 15^s, and upwards, as their direction became more oblique: the nearest vertical flash therefore indicated an altitude of 9,000 feet for the under side of the cloud. At sunset (6·50 p.m.) a streak of sky was visible in the west; this indicated the margin of the storm cloud, and at 8·50 p.m. it passed over Sydney. Therefore, as the clouds were at least 9,000 feet high, we have a probable velocity of storm translation of fully 50 miles per hour. Again, taking the time it reached Grenfell, 5 p.m., and Sydney at 7·30 p.m., we have an interval of $2\frac{1}{2}$ hours for 170 miles; or at the rate of 68 miles per hour, which is a very close agreement with that deduced from the observations on the clouds themselves; and it is a velocity quite sufficient to account for the remarkable increase in pressure shown by the barograph, which at 6·20 p.m. amounts to fully 0·250 in. above the probable height which the barometer, if there had been no storm, would have shown at that time. The facts which I have already stated indicate that this storm-cloud was of very large dimensions, fully 200 miles in diameter; and, if we examine the barograph curve, we find a sudden rise or increase of pressure at 5·10 p.m., and the sudden fall in the wake of the storm begins at 9·20 p.m.—that is 4 hs. 10 min.; and taking a mean of the two determinations of the velocity, 50 and 68 miles per hour, we get 59 miles for the rate of progress, or 246 miles from the wane of pressure in front to the partial vacuum in the rear. I much regret that the other observers on the line of this storm did not give particulars about the times; but the facts, so far as they go, are so accordant that I think there can be but little doubt that this storm was of the dimensions given, and travelled with a velocity of fully 50 miles per hour. There are several interesting circumstances which I have been obliged to omit, for I have already far exceeded the space allotted to these notes.

Discussion.

Mr. Conder said he was taking observations in connection with the trigonometrical survey party near Carcoar when this storm occurred. They were on the outside edge of the storm. From half-past 5 till 6 o'clock he was trying to see the station at Carcoar, but could not see it; the storm-cloud was then passing over Carcoar. He was a little to the east of the station.

Mr. Scott: What was the greatest velocity of the wind registered at the Observatory?

Mr. Russell: 153 miles an hour.

Mr. Scott: Then the rate at which the storm appeared to travel was not improbable. The increased atmospheric pressure could hardly be produced by the thunder-cloud; the action of the cloud could not be compared to that of a ship passing through the water, as the cloud was carried by the wind, and did not drive the wind before it. Probably the rapid changes in pressure were caused by eddies in the air resembling a cyclone on a small scale. When such a whirlwind passed over a spot the barometer would rise, then fall as the centre passed over, then rise again.

Mr. Russell said he forgot to mention that masters of vessels passing along the coast on the afternoon of the storm could not depend on the wind for 5 minutes. The wind appeared to be going round the compass all the afternoon. The velocity of wind at the Observatory was very small indeed—from 8 to 20 miles per hour. It appeared from the wind register to have been a double storm.

Professor Smith said that these observations were extremely interesting, but at the same time puzzling. No doubt the vortex theory might account for some of the barometrical changes; but about the thunder-cloud, they could not imagine it to be like a ship going through the water. How was a thunder-cloud formed? It must certainly be by the meeting and mixing of two winds. Take the thunder-storms that rose here from the south-west: we saw peculiar rolling clouds coming from the south-west, evidently formed by the meeting of a cold south-westerly wind with the warm moist north-easterly; from the mixing of the two winds it was easy to see how they produced a deposition of moisture and the thunder-cloud was formed. It was formed by the invisible moisture becoming visible, and its electricity being now restricted to a smaller surface the intensity increased so as to form lightning. The velocity of the upper wind determines the velocity of the cloud. The upper, cold wind probably came on in a series of waves, like the tide-bore in the Hoogley, and so caused a successive rising and falling of the barometer.

The Chairman asked if dry seasons had any influence in the formation of these frequent thunder-storms. His experience was that in dry seasons thunder-storms were frequent. In moist seasons we had never had thunder-storms at all.

Mr. Russell said: The cause of thunder-storms is the meeting of the tropical and polar winds. The tropical is in summer a hot, dry wind, charged with electricity, and when a cold wind meets this the vapour gets condensed, and, as Professor Smith has explained, the electricity becomes distributed over fewer and larger water particles, which cannot take the whole charge, and the excess appears as disruptive discharges. Now, this meeting-ground of the two winds varies with the trades. In a hot summer the trade comes farther south, and we are in the latitude of the margin, and therefore in the latitude of thunder-storms; while in an ordinary year the meeting-ground of the two winds is north of us, and we have few storms. That the immediate cause is this meeting, I think, is proved by an investigation I went into last year, when I found, on examining 195 thunder-storms, that the two currents (tropical and polar) could be traced in 178. The fact that during the past two warm years we have had few storms seems to be opposed to the opinion here stated; but I think it could be explained in accordance with this view, only it would take me too long at this late hour. With regard to the vortex theory which Mr. Scott has suggested, I think we can hardly accept it as an explanation, for in all these cases the barometer shows a rise with the storm, whereas in hurricanes and smaller revolving storms the barometer always falls as the storm comes on, and rises as it goes off. Now, in America a theory has been ably put forward to account for the storms which are so frequent there. It has not been generally accepted, but it is in accordance with very many observed facts. According to this theory, when the tropical and polar currents meet, one passes above the other, and the actual plane of meeting is inclined to the surface of the ground, and the two surfaces are just in that condition when, in accordance with well-known laws, a vortex motion may originate from a small disturbing cause, such as an abrupt hill, and having once started, it travels with great velocity in the plane of the meeting. And I think it is not at all difficult to conceive that a vortex so originated by winds having the velocity of 70 or 80 miles per hour, as I have shown ("Climate of New South Wales") our upper currents to possess, may travel forward as an independent mass, with a velocity such as I have shown this storm of November 27 to have had. We see that such vortices do sometimes form, by the havoc they make in passing through our forests, but whether such a vortex mass passing through the air and not reaching the ground would cause the increase of pressure recorded by the barograph or not; I am not sure. I think it would, and that in its wake there would be a corresponding vacuum. Of course, pressure exerted on a fluid is distributed all over it, but when large spaces are concerned this takes time, and we know from many experi-

ments that when a gale of wind blows against a high wall, the barometer shows a greater pressure to windward than to leeward, but theoretically it should not do so. And another fact which all who have watched the barometer here will remember, as soon as I mention it is, that when a southerly gale comes on, the barometer rises rapidly, and this is owing to the pressure exerted by the incoming wind forcing up the local wind, as may be seen in the peculiar rolling clouds, and in the fact that such a wind with a velocity of from 60 to 70 miles per hour will take from one and a half to two hours to travel from here to Newcastle, a distance of 60 miles. I confess I have some difficulty in accepting some of the conclusions which an investigation of this storm have led me to. But whether we accept its velocity and size or not, there can be no question that thunder-storms do affect the barometer as I have stated—that is, by a sudden rise as they come in, and an equally sudden fall after they are past.

PROCEEDINGS.

PROCEEDINGS

OF THE

ROYAL SOCIETY OF NEW SOUTH WALES.

WEDNESDAY, 2 MAY, 1877.

ANNUAL General Meeting of the Royal Society of New South Wales, held in the Society's Rooms, Elizabeth-street.

Mr. H. C. RUSSELL, F.R.A.S., V.-P., in the Chair.

The Annual Report of the Council was then read:—

"The Council begs to bring before the members a statement of the position of the Society and its progress during the last year.

"This progress, both in the number of members and general activity, is very encouraging, and justifies the hope that the Society is steadily advancing to that position of usefulness which our venerable Vice-President, the Rev. W. B. Clarke, had in view when alluding to its future, in his anniversary address of 1875.

"At the end of 1875 there were 176 members on the roll. 132 new members were elected in 1876, making 308 members, of whom three died during 1876–77, and seven withdrew, leaving 298 members at the beginning of this session of 1877.

"The financial position of the Society will best be seen by a glance at the balance sheet of the Honorary Treasurer, which shows that the receipts for the year were £413 12s.—the expenditure, £389 5s. 2d.—leaving, together with the balance brought over from the previous year, a Bank balance of £128 3s. 2d. to the credit of the Society.

"The most potent agency for bringing about a greater activity and a large increase in the number of members consisted in the establishment of Sections, which were formed during last year; and though a new experiment it may fairly be considered as a very successful one. These Sections were originally formed under nine heads, viz.—Astronomy, Chemistry and Mineralogy, Geology, Biology, Microscopy, Geography, Literature and Fine Arts, Medical, Sanitary and Social Science.

"Geology was temporarily amalgamated with Chemistry and Mineralogy, while the Section for Biology lapsed for the time being. As the preliminary meetings of each Section were not held till towards end of June, the actual work did not begin till July.

"In accordance with the By-laws, reports on the working of each Section were received by the Council from the Chairmen of the respective Sections. From these reports it appears that while several Sections were well attended and actively supported by the members, others may still be considered as only in their preliminary stage, and the Council hopes that the session now commencing will bring each Section into full and vigorous activity.

"The general meetings of the Society held during 1876 were, in addition to the annual Conversazione, which was held at the Masonic Hall on the 3rd of May, eight ordinary meetings and two extra meetings held at the Society's rooms. The meetings of the various Sections were held monthly at the Society's rooms.

"The Council has decided to publish the papers read at these meetings, as well as an Abstract of its Proceedings and those of the Sections, under the (for a small Society) less pretentious name of 'Journal,' instead of 'Transactions' as before.

"The Council much regrets the unavoidable delay in the issue of the Journal for 1876, which they hope, however, will be in the possession of members before long.

"During last year, a very large number of the Society's 'Transactions,' together with many other scientific publications issued by the Government, relating to this Colony, were forwarded by the Council to different Scientific Institutions in England, America, and the Continent of Europe. The Society has thus become one of the most effectual agencies for making this Colony favourably known abroad.

"Already a very numerous and valuable collection of books and pamphlets, received as donations in return for those just referred to, forms the nucleus of a future very valuable scientific library; and to this end the Council have also during last year subscribed, through Messrs. Trübner & Co., in London, for twenty-five different scientific periodicals—English, French, and German.

"The acquisition of these books and scientific periodicals has already filled up most of the available space at the Society's rooms.

"The Council has decided to open the rooms of the Society for three evenings each week during the eight months of the session—viz., on Monday, Wednesday, and Friday, from 7 to 10 o'clock—to enable members to make use of the books and periodicals.

"For the present, the Council has deemed it unadvisable to allow any books or periodicals to be taken away from the Society's rooms by any of the members; but as soon as the books are properly arranged and catalogued such advantage will be readily conceded, under proper restrictions.

"In May last a deputation elected by the members of the Society waited upon the then Minister of Justice and Public Instruction, with a view of urging upon the Government the

claim of the Society to a liberal assistance in the shape of an annual endowment, and also a lump sum towards providing a suitable building for the Society.

"This deputation was courteously received by the Minister, who promised to bring the matter before his colleagues.

"The change of Ministry, which has since occurred, prevented this matter being brought to the desired issue. It has, however, quite lately been brought under the favourable consideration of the Hon. the Colonial Secretary, and the Council feel confident that both the Government and Parliament will take a liberal view of the position of this Society and its requirements.

"In such a case its usefulness will be largely increased, while at present the want of adequate funds prevents the Council from carrying out some of the most essential means for effecting such results".

At the conclusion of the Report, Dr. LEIBIUS informed the members of the Society that Mr. Catlett, who had been Assistant Secretary for over twenty years, had, in consequence of the increased duties entailed by the enlarged sphere of the Society, been compelled to tender his resignation, which the Council accepted with much regret.

Mr. W. H. Webb had since been appointed as Assistant Secretary.

The following Financial Statement for the year ending 30th April, 1877, was read by the Rev. W. SCOTT, M.A., Honorary Treasurer:—

RECEIPTS.

	£	s.	d.
To Balance in the Union Bank on the 30th April, 1876	98	16	4
" Subscriptions and entrance fees	413	12	0
	512	8	4

DISBURSEMENTS.

	£	s.	d.
By Rent of Rooms from 1st Feb., 1876, to 30th April, 1877	62	10	0
" Office-keeper (Mrs. Casey) to 9th April, 1877	8	11	6
" Hire of Masonic Hall for Conversazione	5	5	0
" Refreshments do. do.	15	0	0
" Sundry expenses do. do.	16	5	7
" Refreshments for Monthly Meetings	19	16	0
" Office furniture and effects	57	16	8
" Stationery and Printing Account	82	11	11
" Advertisements	19	0	1
" Postage and Petty Cash Account	37	6	2
" H. W. Ingram (Collector) Commission	8	16	3
" Rev. W. Ridley, Reporting	6	6	0
" Assistant Secretary's salary, from 1st January 1876, to 31st March, 1877	50	0	0
" Balance in the Union Bank on 30th April, 1877	123	3	2
	£512	8	4

ASSETS.

	£	s.	d.
To Balance in the Union Bank	123	3	2
„ Subscriptions and entrance fees due	36	15	0
„ Furniture, books, and pictures, as insured	250	0	0
	£409	18	2

LIABILITIES.

By Frederick White, printing account	21	7	6
„ S. T. Leigh & Co., do. do.	45	0	0
„ Assistant Secretary	23	6	8
„ Periodicals ordered	30	0	0
„ Balance of Assets over Liabilities	290	4	0
	£409	18	2

The statement was adopted.

A ballot was then taken, and the following gentlemen were duly elected officers and members of Council for the current year :—

PRESIDENT
(*ex-officio*) :
HIS EXCELLENCY SIR HERCULES ROBINSON, G.C.M.G., &c., &c., &c.

VICE-PRESIDENTS:
REV. W. B. CLARKE, M.A., F.R.S., F.G.S.
CHRISTOPHER ROLLESTON.

HONORARY TREASURER:
REV. W. SCOTT, M.A.

HONORARY SECRETARIES:
PROFESSOR LIVERSIDGE. DR. ADOLPH LEIBIUS.

COUNCIL:

FAIRFAX, JAMES R.	RUSSELL, H. C., B.A., F.R.A.S.
JONES, P. SYDNEY, M.D., M.R.C.S.	SMITH, HON. J., C.M.G., M.D.
MOORE, CHARLES, F.L.S.	WRIGHT, H. G. A., M.R.C.S.

The following gentlemen were balloted for and declared duly elected ordinary members of the Society :—

Arthur Burnell, Survey Office.
Alfred J. Cape, Pitt-st.

The certificates of eight new candidates were read.

The CHAIRMAN announced that arrangements had been made for the Council Room to be opened as a Reading Room three nights a week to the members during the session.

It was stated by the CHAIRMAN that arrangements had been made for the various Sections to hold meetings during the ensuing year, a card of which would when finally settled be printed for distribution amongst the members.

A list showing provisional arrangements had already been issued as follows :—

SECTIONS.

At 8 o'clock p.m.

	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
A—Astronomy, &c., Wednesday	9	13	11	8	12	10	14
B—Chemistry, C—Geology } Friday	18	15	20	17	21	19	16
D—Natural History & Botany, Monday	7	4	2	6	3	1	5
E—Microscopy, Wednesday	23	27	25	22	26	24	28
F—Geography, Monday	14	11	9	13	10	8	12
G—Literature and Art, Friday	25	22	27	24	28	26	23
H—Medical, Friday	11	8	13	10	14	12	9
I—Sanitary, Monday	21	18	16	20	17	15	19

Upwards of two hundred donations were laid upon the table.

Letters were read from the following gentlemen acknowledging their election as honorary members of the Society, viz. :—

Sir James Cockle, M.A., F.R.S., Chief Justice of Queensland.
Professor L. G. De Koninck, M.D., University of Liege.

The Rev. W. SCOTT, M.A., moved—

"That in future no motion be made of which notice had not been given at a previous meeting, excepting motions of adjournment or others of a formal character."

The Hon. J. SMITH, C.M.G., M.D., LL.D., seconded the resolution, which was duly carried.

Mr. H. C. RUSSELL, B.A., F.R.A.S., Vice-President, then read his address, and referred to some of the more important scientific discoveries and improvements of the past year.

WEDNESDAY, 16 MAY, 1877.

The annual Conversazione given by the Society was held in the Masonic Hall, York-street, at 8 p.m. on the evening of May 16th, 1877; the gathering was very large, and the evening passed off most pleasantly and successfully.

Members on this, as on former similar occasions, were allowed to introduce the ladies of their families.

The total number of guests (including members, their ladies, and other friends who had received cards of invitation from members of the Council) present was between five and six hundred. In this respect the Conversazione surpassed the one given last year, when four hundred guests were present in response to the invitations issued on that occasion.

The Vice-Presidents and Council received the visitors at the western entrance to the large hall, in which room the principal objects of interest were exhibited.

The entrance hall in York-street, the supper-room in which refreshments were served during the evening, and the large hall were handsomely decorated by Mr. Charles Moore, F.L.S., Director of the Botanic Gardens, with green foliage, ferns, palms, and rare and choice plants from New Guinea.

The Band of the New South Wales Artillery played a selection of music during the evening.

The dark room was occupied by Mr. H. C. Russell's large Ruhmkorff coil and electrical apparatus, with which he repeated series of experiments from time to time during the evening.

A very large number of most interesting objects and pieces of apparatus were exhibited, the necessary references to which were made in the printed catalogue.

The Conversazione Committee consisted of the following members of the Council:—

Mr. H. C. Russell B.A., F.R.A.S.
Mr. Chas. Moore, F.L.S.
Professor Liversidge.
Dr. A. Leibius.

WEDNESDAY, 6 JUNE, 1877.

Ordinary monthly meeting of the Royal Society of New South Wales, held in the Society's rooms, Elizabeth-street.

The Rev. W. B. Clarke, M.A., F.R.S., V.P., in the Chair.

The minutes of the last meeting were read and confirmed.

The following gentlemen were duly elected ordinary members of the Society, viz.:—

Griffith Evan Russell Jones, B.A., 382, Crown-street, Surry Hills.
Norman Selfe, C.E., Balmain.
H. C. L. Anderson, M.A., Sydney Grammar School.
G. Kopsch, 8, Bridge-street.
W. Moore White, LL.D., Elizabeth-street.
Rev. Jacob Olley, Hunter's Hill.
Josiah Mullens, Hunter-street.
Percival R. Pedley, 1, Carlton Terrace, Wynyard Square.

The certificates of twenty-six new candidates were read.

Professor Liversidge stated that the different Sections of the Society had held their preliminary meetings and elected their officers for the current year.

One hundred and thirty-four pamphlets and nineteen volumes were laid upon the table.

A paper on the "Sphenoid, Cranial Bones, Operculum, and supposed Ear Bones of *Ctenodus*," and on the "Scapula, Coracoid, Ribs and Scales of *Ctenodus*," by Mr. W. J. Barkas, M.R.C.S., was read.

The Rev. W. B. CLARKE then read a paper entitled "Notice of a new fossil gigantic Bird of Australia, now named *Dromornis Australis*" (Owen).

Mr. ALFRED ROBERTS then read a paper on "The Liernur System of Sewage, its application to Hospitals and Towns." The paper was illustrated by several diagrams.

Mr. H. C. RUSSELL exhibited an improved form of bichromate battery, by which the current of electricity generated is kept quite constant so long as it may be required. This is accomplished by allowing the bichromate solution to drop in slowly, and flow out at the same rate through a pipe which commences at the bottom of the cell and passes through the side, at three-quarters of an inch from the top. When the supply tap is turned, the solution collects in the cell until it rises to the level of the pipe, and it then begins to pass out as fast as it comes in. As the bichromate solution passes down the cell its active properties are made use of, and when it reaches the bottom it is waste, and passes out as described. In use it is found that both the zinc and the salt solution are more economically used than in the ordinary bichromate cell.

WEDNESDAY, 4 JULY, 1877.

The REV. W. B. CLARKE, V.P., in the Chair.

The minutes of the last meeting were read and confirmed.

The following gentlemen were duly elected ordinary members of the Society:—

Dr. Tucker, Superintendent, Bay View Asylum, Cook's River.
Thomas Bladen, Pyrmont.
J. K. Hume, Cooma, Yass.
W. E. Jennings, B.A., Mining Department, Sydney.
Lawrence Hindson, Careening Cove, North Shore.
John Kinloch, M.A., Sydney.
Edward Knox, jun., Fiona, Double Bay.
Alfred Joseph Watt, Ashfield, Parramatta Road.
A. C. Fraser, North Shore.
Algernon H. Belfield, Eversleigh, Armidale.
Julius Anivitti, Artist, Academy of Art.
Francis A. Adams, Sydney.
F. M. Darley, M.A., Sydney.
W. C. Bundock, Wyangarie, Casino.
Thomas Kingsmill Abbott, P.M., Gunnedah.
— Abbott, Gunnedah.

John Bennett, Sydney.
Fredk. Evans Sloper, 96, Oxford-street, Sydney.
Samuel MacDonnell, 326, George-street, Sydney.
John Keep Broughton, Petersham.
Lawrence Hargrave, Supreme Court.
John Mann, Neutral Bay.
Thomas Slattery, Manly Beach.
William Morris, L.F.P., S.G., Wynyard-square, Sydney.
George Pile, Margaret-street, Sydney.
J. P. Garvan, 130, Elizabeth-street, Sydney.

The certificates of nine new candidates were read.

Professor Liversidge announced the following names of the Committee-men of the different Sections of the Society, viz.:—

Section A—*Astronomical and Physical Science.*—Chairman: H. C. Russell, B.A., F.R.A.S. Secretary: W. J. MacDonnell. Committee: Rev. G. Martin, H. G. A. Wright, M.R.C.S., G. D. Hirst, H. A. Lenehan.

Section B *and* C—*Chemistry and Geology.*—Chairman: Professor Liversidge. Secretary: W. A. Dixon. Committee: S. L. Bensusan, J. S. Sleep, G. A. Morrell, C.E., J. W. M'Cutcheon.

Section D—*Natural History and Botany.*—Chairman: R. D. Fitzgerald, F.L.S. Secretary: Arthur S. Stopps. Committee: James Norton, E. Daintrey. Curator of Herbarium: W. D. Armstrong.

Section E—*Microscopy.*—Chairman: A. Roberts, M.R C.S., Secretary: G. D. Hirst. Committee: Rev. G. Martin, Hugh Paterson, J. Milford, M.D., M.R.C.S., W. MacDonnell.

Section F—*Geography.*—Chairman: E. Du Faur, F.R.G.S. Secretary: W. Forde. Committee: Hon. L. F. DeSalis, E. L. Montefiore, James Manning, H. A. Gilliat.

Section H—*Medical Science.*—Chairman: Dr. Neild. Secretaries: Dr. Sydney Jones, Dr. M'Laurin. Committee: H. G. A. Wright, M.R.C.S., Dr. Milford, Dr. Schuette, Dr. O'Reilly.

Section I—*Sanitary and Social Science.*—Chairman: Alfred Roberts, M.R.C.S. Secretary: Harrie Wood. Committee: H. W. Jackson, L.R.C.S., &c., W. J. G. Bedford, M.R.C.S., Dr. Belgrave, W. G. Murray.

Twenty-two volumes and fifty-eight pamphlets were laid upon the table.

The Chairman mentioned that Mr. James Norton had presented to the Society bound files of the *Sydney Morning Herald* from 1862 to 1872, and the sequent numbers up to the present date unbound.

Mr. H. C. Russell, B.A., F.R.A.S., gave notice that at the next meeting he should move the following resolution, viz.:—"That a Committee be appointed for the purpose of collecting money towards building or purchasing a home for this Society, and securing the money voted by Parliament towards this object."

The Rev. J. E. Tenison-Woods, F.G.S., F.R.G.S., hon. member, having been introduced by the Chairman, then read his paper "On Australian Tertiary Geology, and some new species of Polyzoa."

Professor Liversidge then read a paper "On the occurrence of Chalk in the Pacific Islands," and exhibited the specimens on which the paper was founded.

WEDNESDAY, 1 *AUGUST*, 1877.

Mr. Christopher Rolleston, V.-P., in the Chair.

The minutes of the last meeting were read and confirmed.

The following gentlemen were duly elected ordinary members of the Society:—

James Henry, 754, George-street.
Andrew Cunningham, Queanbeyan.
W. J. Weston, Union Club.
Edward R. Fairfax, 177, Macquarie-street.
Henry A. Perkins, Ocean-street, Woollabra.
T. T. Gurney, M.A., Professor of Mathematics, University of Sydney.
William Clarke, E. S. & A. C. Bank, Pitt-street.
James A. Paterson, Union Bank, Pitt-street.
George Lee Lord, Woolloomooloo.

The certificates of six new candidates were read.

Professor Liversidge announced that the Journal for 1876 had been received from the Government Printer, and would be distributed to the members of the Society without delay.

Seventy-seven donations were laid upon the table.

Mr. H. C. Russell, B.A., F.R.A.S., moved the following resolution:—"That a Committee be appointed for the purpose of suggesting how the sum of £500, voted by Parliament to aid in the erection of a permanent home for this Society, shall be obtained," and proposed that the Committee consist of the following gentlemen:—

Mr. Josiah Mullens.
Mr. A. S. Webster.
Rev. W. Scott, M.A.
Professor Liversidge.
Dr. Leibius.
Mr. H. C. Russell, B.A., F.R.A.S.

The resolution was duly carried.

Mr. W. A. Dixon, F.C.S., then read his paper "On a new method of extracting Gold, Silver, and other metals from Pyrites."

Mr. H. C. Russell, Government Astronomer, exhibited a new form of Crooke's Radiometer, and briefly explained its mode of action.

Professor Liversidge, at the request of Mr. P. N. Trebeck, drew attention to two large specimens of columnar sandstone from the head of Lane Cove, and briefly explained that the columnar structure had probably been set up in the sandstone at that place by the "baking action" of a dyke or overflow of basalt similar to the well-known instance at Bondi. He further stated that the same thing was often observed in the hearths of blast furnaces, where the sandstone floor, after exposure to the intense heat of the molten iron for some time, gradually became partially vitrified and split up into columnar masses, showing like the specimens exhibited a more or less regular polygonal form. Mr. Trebeck he understood wished to present the specimens on the table to the Society.

WEDNESDAY, 5 *SEPTEMBER*, 1877.

Mr. Christopher Rolleston, V.P., in the Chair.

The minutes of the last meeting were read and confirmed.

The following gentlemen were duly elected ordinary members of the Society:—

Neville Griffiths, the Domain, Sydney.
A. W. Anderson, Union Club, Sydney.
Thos. James Thompson, Pitt-street, Sydney.
Edward Lloyd Jones, 345, George-street, Sydney.
Richard Read, M.D., Singleton.
Charles James Fache, Cleveland House, Redfern.

The certificates of four new candidates were read.

The following report from the Finance Committee was brought up:—

"The Committee appointed for the purpose of suggesting how the sum of £500 voted by Parliament to aid in the erection of a permanent home for this Society shall be obtained, recommend that an appeal be made by the Council to the members of the Society and others for subscriptions in aid of the Building Fund.

The motion was put and passed, there being only two dissentients.

Ten donations were laid upon the table.

A statement of exchanges and presentations made by the Royal Society of New South Wales was distributed amongst the members, and the following list of publications received for distribution was read:—

"From the Hon. the Colonial Secretary, *per* Mr. Charles Potter, Acting Government Printer, 200 copies Essay on New South Wales; 100 copies Climate of New South Wales; 20 copies Kamilaroi. From the Under Secretary for Mines, 200

copies Mining Report for 1876. From the Commissioner for Railways, 100 copies Report of Railways, New South Wales. From the Government Astronomer, 100 copies Climate of New South Wales. From the President of the Council of Education 50 copies of the Report of the Council of Education for 1876."

The following letter from the Colonial Secretary was read:—

The Principal Under Secretary to Professor Liversidge.

Colonial Secretary's Office,
Sydney, 7 September, 1877.

Sir,

In acknowledging the receipt of your letter of the 30th of last month, enclosing a printed paper setting forth the manner in which the publications supplied by the Government to the Royal Society of New South Wales have been distributed, I am directed by the Colonial Secretary to express to you his approval of what has been done and the satisfaction with which he has received this account of the distribution of those publications.

I have, &c.,
HENRY HALLORAN.

Professor Liversidge announced that the Journal of the Society for 1876 had been distributed to all members entitled to it for the current year.

The Rev. J. E. Tenison-Woods, F.G.S., F.R.G.S., then read his paper on "The Palæontological Evidence of Australian Tertiary Formations."

A paper entitled "A Synopsis of Australian Tertiary Fossils," by Mr. R. Etheridge, junr., F.G.S., was read.

WEDNESDAY, 3 OCTOBER, 1877.

Ordinary monthly meeting of the Royal Society of New South Wales, held in the Society's Rooms, Elizabeth-street.

Christopher Rolleston, V.-P., in the Chair.

The minutes of the last meeting were read and confirmed.

The following gentlemen were duly elected ordinary members of the Society:—

William Edward Warren, M.D., M.R.C.S., 26, College-street, Sydney.

Rev. C. F. Garnsey, St. James's Parsonage, Sydney.

Joseph Palmer Abbott, Murrurundi.

The certificates of five new candidates were read.

Seventeen donations were laid upon the table.

A paper on "Ctenacanthus, a Spine of Hybodus," by Mr. W. J. Barkas, M.R.C.S., was taken as read.

The Hon. J. Smith, C.M.G., M.D., &c., then read his paper on "A System of Notation adapted to explaining to Students certain Electrical Operations."

The following papers on "Guano and other Phosphatic Deposits, Maldon Island," and "Notes on the Meteorology, Natural History, &c., of a Guano Island," were then read by Mr. W. A. Dixon, F.C.S.

WEDNESDAY, 7 NOVEMBER, 1877.

Ordinary monthly meeting of the Royal Society of New South Wales, held in the Society's Rooms, Elizabeth-street.

CHRISTOPHER ROLLESTON, V.-P., in the Chair.

The minutes of the last meeting were read and confirmed.

The following gentlemen were duly elected ordinary members of the Society:—

George Bennett, Toowoomba, Queensland.

T. A. Tenison-Woods, Phillip-street, Sydney.

James Merriman, Mayor of Sydney.

The Hon. E. A. Baker, M.P., Minister for Mines, Sydney.

Sir J. G. L. Innes, Knt., Darlinghurst.

The certificates of three new candidates were read.

One hundred and six donations were laid upon the table.

A paper on "Tertiary Corals," by the Rev. J. E. TENISON-WOODS, F.G.S., F.R.G.S., was then read by Professor Liversidge.

Mr. H. C. RUSSELL, B.A., F.R.A.S., read "Some Notes on the recent Opposition of the planet Mars," illustrated by a number of photographs of the planet, taken in Sydney, and reduced.

Professor LIVERSIDGE exhibited some interesting specimens of carbonate of lime deposited upon bundles of yarn brought from the Thames Gold Fields, New Zealand, by Mr. Fitzwilliam Wentworth, as showing the rapidity with which these deposits are made under favourable circumstances.

WEDNESDAY, 5 DECEMBER, 1877.

Ordinary monthly meeting of the Royal Society of New South Wales, held in the Society's Rooms, Elizabeth-street.

C. ROLLESTON, V.-P., in the Chair.

The minutes of the last meeting were read and confirmed.

The following gentlemen were duly elected ordinary members of the Society:—

L. M. Harrison, Moira, Burwood.

John Field Deck, M.D., 251, Macquarie-street.

H. S. Hawkins, M.A., Balmain.

The certificates of two new candidates were read.

Twenty-three donations were laid upon the table.

The following papers were read:—

1. On a new and remarkable Variable Star in the Constellation Ara, by John Tebbutt, F.R.A.S., &c.

2. On a Dental peculiarity of the Lepidosteidæ, by W. J. Barkas, L.R.C.P.L., &c.

3. Notice of a New Fossil Extinct Species of Kangaroo, *Sthenurus minor*, by Rev. W. B. Clarke, M.A., F.R.S., &c.

4. Notes on some recent Barometric Disturbances, by H. C. Russell, B.A., F.R.A.S.

The Rev. W. Scott, M.A., Hon. Treasurer, announced that in response to two circulars the sum of £399 3s. had been promised as subscriptions from sixty members towards the Building Fund; this fell short of the amount required (£1,000) to entitle them to the Parliamentary vote, but it was reasonably hoped that they would yet receive the requisite amount.

The Chairman remarked that as the vote held good for next year, they need not despair about the amount being made up in time.

The following is a copy of the circular and enclosures forwarded to the members of the Society:—

[*Circular.*]

THE ROYAL SOCIETY OF NEW SOUTH WALES.

The Society's Rooms,
Sydney, 13 September, 1877.

Dear Sir,

We have the honor to inform you that, in response to the representations made by the Society, the Government has been pleased to vote the sum of £500 towards the amount requisite to provide the Society with a permanent home, but on the condition that the Society raises the sum of £1,000.

Further, that at the General Monthly Meeting of the members of the Society, held on September 5th, it was resolved that, in order to raise the above amount, an appeal be made for subscriptions.

The Council considers it highly desirable that an earnest endeavour should now be made to obtain a house for the Society, not only to enable the Society to extend its sphere of scientific usefulness, as set forth in the memorandum at foot; but it is also of opinion that it is in the highest degree necessary to do so, inasmuch as the Society holds even its present inadequate accommodation merely as a yearly tenant, and it may at any time have to seek shelter elsewhere.

It is thought that should the Society secure the full amount of £1,500, it will be in a position to obtain a house (one which, with slight alterations, will be suitable for the Society's purposes), when, by judicious management, the Society's annual expenses need not be materially greater than at present; and, moreover, there is every probability that, by sub-letting, the annual expenses could be reduced to even a smaller amount than the rent now paid, viz., £60.

We are also directed to inform you that, to secure the valuable books and other property belonging to it, and to place the Society upon a permanent basis, the necessary legal instruments are now being drawn up to incorporate the Society by charter.

We have the pleasure to inform you that, in addition to the £500 towards a house for the Society, the late Government also voted £200 in aid of current expenses, which will make the income for the present year about £600.

Trusting that you may be favourably disposed towards this object, and willing to contribute to the same,—

We have, &c.,
A. LIVERSIDGE, } Hon.
A. LEIBIUS, } Secretaries.

MEMORANDUM

In re DEPUTATION TO THE GOVERNMENT FROM THE ROYAL SOCIETY OF NEW SOUTH WALES.

Reasons for the application for assistance.

1. *Popular Scientific Lectures.*—To enable the Society to institute courses of popular scientific lectures.
2. *Working Sections.*—To permit the establishment of working Sections of the Society for the promotion of special branches of science.
3. *Scientific Library.*—To enable the Society to form a Library of standard scientific works.
4. *To collect and distribute publications.*—To found a central institution in New South Wales for the exchange of scientific publications between the institutions of this Colony and those of other Countries. Recent experience has shown that the Transactions of this Society will be received as an equivalent for the publications of most of the leading Societies of Europe and America.
5. *Scientific investigations.*—In England, similar scientific Societies afford valuable information to the Government on many subjects. The Royal Society of Sydney has done something in the past, and is anxious to do more in the future.
6. *Insufficient funds.*—The money at its disposal will not permit the Society to maintain even its present relations with the public and other Societies, and it is totally inadequate to carry out the contemplated extended scheme of usefulness.
7. *Other Societies receive aid.*—They feel that they are justified in making this request, because other Societies established here to educate and instruct the public receive grants of money and assistance.
8. *Societies in other Colonies.*—The corresponding Societies in Victoria, New Zealand, and Tasmania, are liberally supported and provided with suitable buildings by their respective Governments.
9. £5,000 *subscribed.*—*Assistance sought*—Since its commencement the Society has subscribed upwards of £5,000 for the

promotion of science and higher education in the Colony; and the undersigned now respectfully ask, in the name of the Society, for assistance from the Government, in order that they may make their past labours and present capabilities of more use to the public. The principal English scientific Societies are provided with suitable accommodation,—Burlington House having been recently rebuilt at great cost expressly for this purpose; and the Royal Society of London has large sums of money annually placed at its disposal by the Government.

W. B. CLARKE, Vice-President.
H. C. RUSSELL, Vice-President.
FRANCIS LORD.
J. S. FARNELL.
A. LANG, D.D.
C. MOORE.
A. LEIBIUS, Honorary Secretary.
A. LIVERSIDGE, Honorary Secretary.

[*Enclosure No.* 1.]

I HEREBY promise to contribute to the Building Fund of the Royal Society of N.S.W. the sum of £ on condition that the full amount of £1,000 be obtained necessary to secure the Government grant of £500.

(Signed)
(Address)

(Date)

[*Enclosure No.* 2.]

PRELIMINARY LIST OF SUBSCRIPTIONS promised towards the Building Fund of the ROYAL SOCIETY OF NEW SOUTH WALES, November 12th, 1877 :—

	£	s.	d.
Brodribb, W. A., F.R.G.S., Double Bay	10	10	0
Clarke, Rev. W. B., M.A., F.R.S., North Shore	5	5	0
Fairfax, Edward, 177, Macquarie-street	10	10	0
Fairfax, James R., Double Bay	20	0	0
Hay, Hon. John, M.A., Rose Bay	20	0	0
Hume, Frank, Gunning	5	5	0
Josephson, J. F., F.G.S., Judge	20	0	0
Jones, P. Sydney, M.D., College-street	10	0	0
Liversidge, Professor, The University	10	0	0
Leibius, Dr. Adolph, The Royal Mint	5	0	0
Murray, W. G., 52, Pitt-street	5	0	0
Morehead, R. A. A., 30, O'Connell-street	10	0	0
Mullens, Josiah, 34, Hunter-street	10	0	0
Russell, H. C., B.A., F.R.A.S., Government Astronomer ...	10	0	0
Rolleston, Christopher, Auditor General	10	0	0
Scott, Rev. W., M.A., St. Paul's College	5	0	0
Smith, Hon. J., C.M.G., M.D., &c., The University	5	0	0
Tucker, G. A., Superintendent, Bay View Asylum	10	10	0
Ward, W., Oxford-street	5	0	0
Webster, A. S., Union Club	10	0	0
Wright, H. G. A., M.R.C.S.	5	0	0

ADDITIONS

TO THE

LIBRARY OF THE ROYAL SOCIETY OF NEW SOUTH WALES.

DONATIONS—1877.

The names of the Donors are in *Italics*.

REPORTS, OBSERVATIONS, &c.

ADELAIDE:—South Australian Institute, Library Catalogue Supplement.
Do. do. Reports from 1861–2 to 1875–6.
Do. do. Annual Report 1876-7. (Two copies.)
The Institute.

Meteorological Observations made at the Adelaide Observatory during the months of January, February, March, April, May, June, July, August, September, October, November, 1876.
Chas. Todd, C.M.G., F.R.A.S.

Report of the Progress and Condition of the Botanic Gardens and Government Plantations during the year 1876. *Dr. Schomberg.*

The Opening Ceremony of the Palm House in the Botanic Gardens, Adelaide. (Two copies.)

AUCKLAND:—Report of the Auckland Institute, 1875–76, 1876–77.
The Institute.

BOSTON:—First Annual Report of the Board of Health of the City of Boston, 1873.
Do., do., do., 1875.
Annual Report of the Boston Board of Trade, 1859, 1860, 1861, 1863, 1864, 1865, 1866, 1867, 1868, 1869, 1870, 1871, 1872, 1873, 1874, 1875, 1876.
Report of the School Committee, Boston, 1873, 1874.
Statistics of the Public Schools of the City of Boston, 1874-75.
Expenditure for the Public Schools. Report of the Committee on Accounts.
The Smithsonian Institution.

The Geographical Distribution of Animals and Plants. Part II. Plants in their Wild State. *Dr. Chas. Pickering.*

BRISBANE:—Report of the Acclimatisation Society of Queensland. 1876.
Lewis A. Bernays, F.L.S.

The Annual Report of the Queensland Philosophical Society. 1877. (Two copies.) *The Society.*

(Seven) Photographs of the Brisbane Reservoir (framed and glazed).
The National Agricultural and Industrial Association of Queensland.

DRESDEN:—Correspondenzblatt der Afrikanischen Gesellschaft. No. 21.
The Society.

FRANKFURT A/M.—Bericht über die Senckenbergische Naturforschende Gesellschaft. 1875–1876.
Abhandlungen herausgegeben von der Senckenbergischen Naturforschenden Gesellschaft. Elfter Band. Erstes Heft (with nine plates).
The Society.

GLASGOW :—The Glasgow University Calendar, 1877–78. *The University.*

GÖTTINGEN :—Nachrichten von der K. Gesellschaft der Wissenchaften und der Georg-August. Universität, 1876.
K. Gesellschaft der Wissenchaften Göttingen.

HEIDELBERG :—Verhandlungen des Naturhistorisch-Medicinischen Vereins zu Heidelberg. *The Society.*

IOWA :—Proceedings of the Davenport Academy of Natural Sciences. Vol. I., 1867–76. *The Academy.*

JENA :—Report from the Society of Natural History of Jena—
VIII. Bd. N.F. 1. Bd. I.
VIII. Bd. N.F. 1. Bd. II.
VIII. Bd. N.F. 1. Bd. III.
VIII. Bd. N.F. 1. Bd. IV.
IX. Bd. N.F. 2. Bd. I.
IX. Bd. N.F. 2. Bd. II.
X. Bd. N.F. 3. Bd. I.
X. Bd. N.F. 3. Bd. Supplement.
X. Bd. N.F. 3. Bd. II.
X. Bd. N.F. 3. Bd. IV.
Morgenbladet :—21, 22, 23, 24—October.
The Society.

KÖNIGSBERG :—Schriften der Physikalisch-ökonomischen Gesellschaft.
Vols. 1 and 2. 1875. (Two copies.)
1867. Parts 1 and 2.
1868. Do. 1 and 2.
1869. Do. 1 and 2.
1870. Do. 1 and 2.
1871. Do. 1 and 2. (Two copies.)
1872. Do. 1 and 2. (Do.)
1873. Do. 1 and 2. (Do.)
1874. Do. 1 and 2. (Do.)

LONDON :—Proceedings of the Royal Colonial Institute. Vol. VI, VII, and VIII.
Report of the Council of the Royal Colonial Institute.
Imperial Federation. By F. Young, Esq.
The Institute.
Proceedings of the Royal Society. Vol. XXV, Nos. 172, 173, 174, 175, 176, 177, 178.
The Society.

Journal of the Linnean Society.
Botany—Nos. 82, 83, 84, 85, 86, 87, 91.
Zoölogy—Nos. 65, 66, 70.
First Report of the Local Government Board, 1871–72.
Second Annual Report do. 1872–73.
Third do. do. 1873–74.
Fourth do. do. 1874–75.
Fifth do. do. 1875–76.
Report of a Committee on Modes of Treating Sewage; with Plans.
Reports of Poor Laws in Foreign Countries.
The Local Government Board.

List of the Linnean Society of London, 1876.
The Society.

Quarterly Journal of the Meteorological Society. Vol. III, No. 21.
The Society.

Royal Historical Society's Transactions. Vols. I, II, III, IV, V.
List of the Royal Historical Society.
Genealogical Memoirs of Scott and the Haliburtons.
The Society.

MANCHESTER :—Transactions of the Manchester Geological Society. Vol. XIV. Parts 6, 7, 8, 9, 10, 11, 12, 13. *The Society.*

MASSACHUSETTS :—

Massachusetts Fire and Marine Insurance Report, 1869–70–71–72–73–74–75.

Massachusetts Life Insurance Report, 1869–70–71–72–73–74–75.

Thirty-fifth Annual Report of the Board of Education, Massachusetts.

Thirty-sixth	do.	do.
Thirty-seventh	do.	do.
Thirty-eighth	do.	do.

State Board of Health of Massachusetts' Report, 1870–71–72–73–74–75.

Railroad Returns in Massachusetts, 1860–62–63–64–65–66–67–69–70–72–73–74–75.

Report on the Statistics of Labour, Massachusetts, 1870–71–74–75.

Registration Reports, Massachusetts, 1858–59–61–62–63–64–65–66–67–68–69–70–71–72–73.

Report of the Auditor of Accounts of the Commonwealth of Massachusetts, 1872–73–74.

Annual Reports of the Bank Commissioners, 1864–65.

Annual Report of the Commissioner of Savings' Banks, 1867–68–69–70–72–73–74.

Report of the Treasurer and Receiver-General of the Commonwealth of Massachusetts, 1872–73–74.

The Smithsonian Institution.

Memoirs of the American Association for the Advancement of Science. I.

Proceedings of the American Association for the Advancement of Science. (Twenty-fourth meeting.)

The Association.

Twelfth Annual Report of the Board of State Charities of Massachusetts, 1874–75. *The Director of the Board.*

Bulletin of Museum of Comparative Zoölogy. Vol. III. Nos. 1, 5, 6, 9, 10, 11, 14, 15, 16.

Memoirs of Museum of Comparative Zoölogy, No. 10.

Annual Report of do. 1874, 1875.

The Museum, Harvard College.

Essex Institute Historical Collection—
Vol. XI. Parts 1, 2, 3, 4.
Vol. XII. Parts 1, 2, 3, 4.
Vol. XIII. Parts 1, 2.

Bulletin of the Essex Institute—
Vol. V, 1873. Vol. VI, 1874. Vol. VII, 1875.

The Institute.

MELBOURNE :—The Victorian Year Book for 1875.

Statistical Register of the Colony of Victoria for the year 1875. Part VIII—Vital Statistics. Part IX—Religious, Moral, and Intellectual Progress.

Statistical Register of the Colony of Victoria, 1876. Part I—Blue Book. Part II—Population. Part III—Finance. Part IV. Part V. Part VI.

Agricultural Statistics, 1876-7—Supplementary Return.
Do. year ending 31 March, 1877.

Reports of the Mining Surveyors and Registrars (Victoria), quarter ending 31 December, 1876.

The Victorian Year Book, 1876-7.

The Government Statist.

Select Plants readily eligible for industrial culture or naturalization in Victoria.

MELBOURNE—*continued.*

Descriptive Notes on Papuan Plants—V.

The Government Botanist.

Report of the Mining Surveyors and Registrars of Victoria, quarters ending 30th September, 1876. *The Registrar General.*

Sixteenth Report of the Central Board of Health, Victoria.

Seventeenth do. do. do.

The Central Board of Health, Melbourne.

Reports of the Mining Surveyors and Registrars of Victoria, quarters ending 31st March, 1877, and 30th June, 1877.

Report of the Chief Inspector of Mines for 1876.

Mineral Statistics of Victoria for 1876.

Geological Survey of Victoria—Report of Progress. No. IV.

The Hon. the Minister for Mines, on behalf of the Government of Victoria.

Melbourne Medical Record.

Do. Vol. VII, No. 3.

The Publishers.

Transactions and Proceedings of the Royal Society of Victoria. Vol. XII.

The Society.

Results of Observations taken at the Melbourne Observatory. Vol. IV. 1875. *The Government Astronomer.*

Prodromus of the Palæontology of Victoria. Nos. 1, 2, 3, and 4.

The Vice Chancellor of the University, Melbourne.

MIDDLESBOROUGH :—The Journal of the Iron and Steel Institute. Nos. 1 and 2, 1876, and No. 1, 1877. *The Institute.*

MISSOURI :—The Transactions of the Academy of Science of St. Louis. Vol. III., Nos. 1, 2, 3. *The Academy.*

PHILADELPHIA :—Report of the Twenty-seventh Exhibition of American Manufacturers, held in the City of Philadelphia, 1874.

Franklin Institute, A.D., 1824–74.

Charter and By-laws of the Franklin Institute.

Theory of the Moon's Motion, by Jno. N. Stockwell, M.A.

The Journal of the Franklin Institute, No. 613, 614, 615, 616, 617, 618, 619, 620, 621, and 622.

The Franklin Institute.

Proceedings of the Academy of Natural Sciences of Philadelphia. Parts I, II, III, 1875.

Do. do. do. Parts I, II, III, 1876.

The Academy.

Philadelphia Centennial Exhibition Commission :—Catalogues, Navy Department Exhibits. (Two copies.)

Seventh Annual Report of the State Board of Health of Massachusetts, January, 1876. (Two copies.)

Thirty-ninth Annual Report of the Board of Education, Massachusetts. (Two copies.)

Fifth Annual Report of the Railroad and Warehouse Commission of the State of Illinois, November 30, 1875. (Five copies.)

Eighteenth Annual Report of the Trade and Commerce of Chicago, for year ending December 31, 1875. (Five copies.)

Thirty-third Report of the Registry and Return of Births, Marriages, and Deaths, in the Commonwealth of Massachusetts.

One hundred and ninety-two Pamphlets.

The Philadelphia Exhibition Commission.

Proceedings of the American Philosophical Society. Vol. XV., No. 96.

"The Rhynchophora of America." *The Society.*

PISA:—Atti della Societa Toscana di Scienze Naturali. Vol. I, fase 3; and Vol. II, fas. 2. *The Society.*

STUTTGART:—Württembergische Jahrbücher für Statistik und Landeskunde herausgegeben von dem K. Statistisch-Topographischen Bureau.
Heft I, II, III, IV. Jahrgang, 1876.
Heft III. Do., 1877.
Konigliche Statistisch-Topographische Bureau zu Stuttgart.

SWITZERLAND:—Bulletin de la Société Vaudoise des Sciences Naturelles. Nos. 69, 70, 71, 72, 73, 74, 75, and 76. *The Society.*

SYDNEY:—Proceedings of the Linnean Society of New South Wales. Vol. I, Parts III, IV; Vol. II, Part I. *The Society.*

A brief extract from the Report of the Voyages of the steamer "Egeron," with Map. *The Hon. the Colonial Secretary.*

Annual Report of the Department of Mines, New South Wales, for the year 1876. *The Secretary for Mines.*

Report of the Construction and Working of the Railways of New South Wales, from 1872 to 1875 inclusive. *The Commissioner for Railways.*

Essay on New South Wales. *The Government Printer.*

Climate of New South Wales. *H. C. Russell, B.A., F.R.A.S.*

Report of the Council of Education on the condition of Public Schools, New South Wales, 1876. *The President of the Council.*

The Journal of the Agricultural Society of New South Wales. Part IV. October, 1877. *The Society.*

TASMANIA:—Papers and Proceedings of the Royal Society of Tasmania. 1875.

TORONTO:—The Canadian Journal of Science, Literature, and History. Vol. XV., Nos. 1, 2, 3, 4. *The Institute.*

TRURO:—The Miners' Association of Cornwall and Devon. Report and Proceedings for the years 1873, 1874, 1875. *The Association.*

The Mineralogical Magazine and Journal of the Mineralogical Society of Great Britain and Ireland. Rules and List of Members. (Two copies.)
Do. do. Nos. 1, 2, 3, 4.
The Society.

VIENNA:—Verhandlungen der Kaiserlich-Königlichen Zoologisch-botanischen Gesellschaft in Wien. XXVI Band, Jan., 1876. *The Society.*

WASHINGTON:—Constitution and By-laws of the American Statistical Association.

Collections of the American Statistical Association. Vol. I., Parts 1, 2, 3.

Increase of Human Life, by Edward Jarvis, M.D. (Three copies.)

Report of the Explorations in 1873 of the Colorado of The West and its Tributaries. (Two copies.)

Vermont Medical Journal. Vol. I., January and March, 1874.

Archives of Science, and Transactions of the Orleans County Society of Natural Sciences. Vol. I., No. 1, October, 1870.

Report of Professor Henry, 1874.

Smithsonian Report, 1875.

A Notice of Recent Researches in Sound.

The Toner Lectures, No. III., on Strain and Over-action of the Heart.

List of Foreign Correspondents of Smithsonian Institution.

Check List of Publications of Smithsonian Institution, July, 1874.

The Constants of Nature, Part II.
The Smithsonian Institution.

Annual Report of the State Geologist. (Geological Survey of New Jersey), 1874–75. *The State Geologist, New Brunswick.*

Congressional Directory, second and third edition, 1876.
The Government Printing Office.

Bulletin of the U. S. National Museum, Nos. 3, 4.
The U. S. National Museum.

WASHINGTON—*continued.*

The Reports of the Superintendent of the U. S. Coast Survey, 1869–70–71–72–73. *The Coast Survey Office.*

Telegraphic Determination of the Longitude in the West Indies and Central America.

An Observing List of Stars. The Hydrographic Office.

Bureau of Navigation.

Report of the Chief of Engineers, 1875. Parts 1, 2.

Annual Report of the Board of State Charities. 1865-66 67 68-69. 1868-69, 1869-70, 1870-71, 1871-72, 1872-73.

Descriptive Catalogue of the Photographs of the United States Geological Survey of the Territories, 1869 to 1875.

Daily Bulletin of the Signal Service, U.S.A.—May, April, June, 1873.

Smithsonian Institution.

Bulletin of the U.S. Geological Survey of the Territories, No. 5—Second Series.

Bulletin of the U.S. Geological and Geographical Survey of the Territories. Vol. II. Nos. 1, 2, 3, 4, and No. 6—Second Series.

Extracts I, II, III, from Vol. II. No. 1.

F. V. Hayden, U.S. Geologist.

Annual Report of the Director of the Mint to the Secretary of the Treasury, 1875. (Two copies.) *Director of the Mint.*

Annual Report upon the Geographical Explorations and Surveys west of the 100th Meridian, in California, Nevada, &c. Appendix LL. 1875.

Report upon New Species of Coleoptera.

Lieut. G. M. Wheeler, Corps of Engineers.

Geological Survey of Indiana, 1870.

Fifth Annual Report of the Geological Survey of Indiana, 1873.

Sixth Annual Report of the Geological Survey of Indiana.

State Geologist, Indianapolis.

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St. Petersburg.—L'Académie Impériale des Sciences. Nos. 1, 2, 3, 4, 7.

SCOTLAND.

Edinburgh.—Geological Society. Nos. 1, 2, 3, 4.
" Royal Physical Society. Nos. 1, 2, 3, 4.
" The Royal Society. Nos. 1, 2, 3, 4, 5.
Glasgow.—Geological Society. Nos. 1, 2, 3, 4.
" The University. Nos. 1, 2, 4, 6.

SPAIN.

Madrid.—Instituto Geografico y Estadistico. Nos. 1, 2, 3, 4, 10.

SWEDEN.

Stockholm.—Kongliga Svenska Ventenskapo-Akademie. Nos. 1, 2, 3, 4, 5.

SWITZERLAND.

Geneva.—Institute National Genevoie. Nos. 1, 2, 3, 4, 5.
Lausanne.—De la Société Vaudoise des Sciences Naturelles. Nos. 1, 2, 3, 4, 5.
Neuchatel.—Société des Sciences Naturelles. Nos. 1, 2, 3, 4.

Number of Publications sent to	Great Britain	306
" " "	The Colonies	70
" " "	America	153
" " "	Europe	517
" " "	Editors of Periodicals ...	20
	Total ...	1,066

A. LIVERSIDGE, } Hon. Secretaries.
A. LEIBIUS, }

The Society's Rooms, Sydney, 19 August, 1877.

REPORTS FROM THE SECTIONS
(IN ABSTRACT).

B

REPORTS FROM THE SECTIONS.

(IN ABSTRACT).

SECTION A.—ASTRONOMY AND PHYSICS.

PRELIMINARY MEETING—9 *MAY*, 1877.

Mr. H. C. Russell, F.R.A.S., in the Chair.

The preliminary meeting of this Section was held on 9th May, 1877, and the following members were appointed as office-bearers for the Session of 1877:—Chairman: Mr. H. C. Russell, B.A., F.R.A.S., F.M.S., &c., Government Astronomer. Committee: Mr. G. D. Hirst, Mr. H. A. Lenehan, Rev. Geo. Martin, and Mr. H. G. A. Wright, M.R.C.S. Hon. Secretary: Mr. W. J. MacDonnell, F.R.A.S.

The Chairman drew attention to the importance of correctly mapping that portion of the Milky Way near the constellation of Crux Australis, as considerable discordances existed between previous representations and the actual appearance of the Galaxy. After discussion the Section adopted the Chairman's proposal, and it was decided that drawings should be prepared for the next meeting.

Mr. Russell exhibited some beautiful drawings of Lissajous's Sound Curves. The patterns were very interesting and intricate, and were drawn by an instrument made from Mr. Russell's instructions by Mr. Lenehan.

FRIDAY, 1 *JUNE*, 1877.

Mr. H. C. Russell, F.R.A.S., &c., in the Chair.

The Rev. Geo. Martin read a paper on "The appearance of that portion of the Milky Way traversing the constellations "Centaurus" and "Crux Australis," accompanied with a drawing illustrating his remarks. The writer stated that he noticed considerable discrepancies in representations of the Galaxy, particularly instancing the part in the vicinity of the two bright stars Alpha and Beta Centauri, which actually seem to lie in the dark opening between the two streams, whereas in most star maps they are represented as being involved in the main stream.

Discussion ensued.

Mr. Russell read some notes on the ever memorable and disastrous storm of 10th Sept., 1876 (the "Dandenong" gale). He traced the course of the gale in its progress through the Colony. The high velocity of the wind (153 miles per hour) registered by the Observatory instruments was confirmed beyond a doubt. Mr. Russell exhibited some maps and drawings in illustration of his paper.

FRIDAY, 6 *JULY*, 1877.

Mr. H. C. Russell, F.R.A.S., &c., in the Chair.

The Chairman exhibited a series of drawings of the "Milky Way" in the neighbourhood of the "Southern Cross." Some of the drawings had been prepared at his request in the early part of 1873, by Messrs. Hirst, Lenehan, Savage, and others; the rest were drawn by himself quite recently. Mr. G. D. Hirst also submitted a drawing of the same part of the Galaxy made during the past month. All these drawings exhibited variations which were more or less attributable to the differenceof eyesight, and the fineness, or otherwise, of the night, but were fairly in accordance with each other. On comparison with the representations made by Dunlop in 1827, and Sir John Herschel in 1837, considerable differences were shown to exist, particularly in the portions surrounding Alpha and Beta Centauri and the "Coal-sack" in the Cross.

Mr. Hirst then presented a drawing in crayon of Jupiter, taken from a Browning, with equatorially mounted reflector of 10¼ inches aperture;—accompanied with a few notes on the present appearance of the planet. He had noticed considerable alteration in the equatorial belt, the central portion of which was now white, in place of being yellow as observed at the opposition of 1876. The green colour of the north polar markings was also much less perceptible this year than formerly.

Mr. Russell stated that, observing the transit of one of the satellites across the disc of the planet, he had been very much struck with the resemblance the satellite in transit bore to one of the white spots occasionally seen in the equatorial belt. Any casual observer might easily have mistaken the satellite for one of the white spots in question. Mr. Russell also gave some particulars about the well-known binary Alpha Centauri. The components are rapidly approaching, and peri-astron will probably occur in 1878. Accurate measures of distance and position are now especially valuable, as considerable discrepancies have been noticed between the predicted and observed places of the two members of this celebrated double star. Mr. Russell had been

taking observations with the large refractor by Schroder of 11⅜-inch aperture, power used 450 diameters; on 5th July, 1877, he found the distance 2″597, angle of position 72°520.

Mr. W. J. MacDonnell exhibited a fine copy in excellent preservation of Scheiner's "Rosa Ursina" folio, Bracciano, 1630. This scarce book, the work of the Jesuit astronomer Scheiner, a contemporary of Galileo, contains one of the earliest published accounts of the spots on the sun's disc, and is profusely illustrated with beautiful steel engravings; it is also interesting from the description of the many difficulties that the first telescopic observers had to conquer in their pursuit of science. Mr. MacDonnell also showed a new form of star-spectroscope made by Browning from designs by Mr. MacClean; the speciality in this instrument consists in the necessity for having a slit being obviated, and in its adaptability to telescopes of 3-inch apertures and upwards.

A discussion on all the points brought before the Section ensued.

FRIDAY, 3 AUGUST, 1877.

Mr. H. C. Russell, F.R.A.S., &c., in the Chair.

The Chairman stated that he had been in correspondence with Mr. H. J. Beatson, late Master R.N., and resident in Levuka, Fiji, relative to the transit of some dark body across the sun's disc on 17th March, 1877. Mr. Beatson had in the first place communicated his observation to the Sydney Observatory, in a letter dated 10th May, 1877, and in reply to a request from Mr. Russell for fuller details he supplied the following account of his observation:—

Levuka, Isle of Ovaulau,
Fiji, 12 July, 1877.

H. J. Beatson, Esq., to H. C. Russell, Esq.

Dear Sir,

Your favour of 28th June is to hand, and in reply thereto I beg to subjoin the following account of my observation on the 17th March last, and much regret I had not been more fully prepared for such an advent, so that a more minute description could have been given.

1st. On 15th and 16th March I observed, though indistinctly, one of the usual spots on the sun's disc, but not larger than usual.

2nd. On 17th March I was using my sextant as usual with a moderately powerful inverting tube, when I observed the first shadow as before described; it was then distinctly clear of the S.E. limb of the sun, the tail or shadow tending downwards to the north.

3rd. The point or head was dark, nearly black, and gradually lighting towards the tail; the tail or shadow was quite transparent graduated into mist.

4th. I have estimated the diameter of head both by calculation and comparison with the same instrument to be ⅔ the size of Jupiter. Of course

I could not well define its exact shape on account of the mist which surrounded it, but the upper portion clear of the mist was sufficiently defined to determine its spheroid form.

5th. Its greatest alt. at 9 h. 6 min. 12 sec. was fully ½ of the sun's disc off the l. l., the shadow nearly reaching to the l. l., but inclining still to the north.

As the shadow passed to the northward, the whole body partook of the elliptical form, as shown in the sketch, the centre rising about 15°–16° from the points of ingress and egress. The shadow was entirely lost as it passed off the sun to the N.E., and the last I saw of it after attentively watching was a mere dark speck, nor was there anything to be observed near the northern l. of the sun afterwards.

March 17th.—This morning was beautifully clear with light S.E. wind, nothing to interrupt the sight, and for that reason I had selected the time to determine the error and rate of chronometer.

Position of point observation, Lat. S....	17 deg.	42 min.	43 sec.
Time E....	11 h.	55 min.	16 sec.
1. Time when shadow was first observed	8 h.	55 min.	15 sec.
„ centre..................................	9 h.	6 min.	46 sec.
„ last contact	9 h.	22 min.	57 sec.
Mean altitude corrected.....................	41 deg.	38 min.	30 sec.
Worked by lat.	17 deg.	43 min.	
Bearing S. 76 deg. E.			

I will be glad at any time to give any further information on this subject in my power, and beg to remain,

Dear Sir,

Yours very faithfully,

HUME J. BEATSON.

Mr. Russell stated that he had forwarded the original letters to M. Leverrier, Astronomer for France, Paris.

Rev. G. Martin read a paper on the appearance of the planet Mars, as viewed in his 5-inch Cooke equatorial; the great south polar snow-cap was prominently visible. Mr. Martin noticed the border of the snow-cap is that of an arc, and seems to cut the disc of the planet like the intersection of a circle—whereas in Warren De La Rue's drawing of Mars at his opposition of 1856 the cap terminates in a bluff point. The other details on the planet's surface were not distinctly made out,—a circumstance probably due to the fact that the intense brilliancy of Mars in Mr. Martin's telescope had blotted them out.

Mr. J. U. C. Colyer exhibited a working model of an observatory he is erecting for his 10¼-inch silvered glass equatorial.

A set of seven eye-pieces for the fine refractor at the Sydney Observatory, made by Schroeder of Hamburgh, were shown by the Chairman. These eye-pieces ranged in power from 130 to 1,500, and constructed after designs by Mr. Russell. A special feature in their construction was the ease with which the lenses could be removed, and consequent lessening of risk of injury when cleaning them.

Mr. Russell further read a paper by Howard Grubb, F.R.A.S. of Dublin, on "The Telescopes of the future," in which the author

entered minutely into the difficulties to be contended with in the construction of large instruments; and after balancing the comparative advantages and disadvantages between reflectors and refractors, finally inclined to the opinion that the Cassegraineau form of reflector would offer least difficulty in any increase of dimension over those now in use. The meeting then terminated.

FRIDAY, 7 SEPTEMBER, 1877.

Mr. H. C. Russell, F.R.A.S., &c., in the Chair.

Both the Chairman and Mr. G. D. Hirst brought several fine drawings of Mars. A comparison between these and the work of observers at former oppositions brought out many points of agreement; sufficient material was not ready to afford a complete collation with the results of previous workers in this field of Astronomy. The great snow-cap surrounding Mars' southern pole had of late decreased considerably in size, owing doubtless to the rapid approach of midsummer to the planet's southern hemisphere. From a mean of several measures Mr. Russell found a polar compression of $\frac{1}{40}$th closely in accordance with Main's results, who makes it $\frac{1}{39}$th; it is to be noted, however, that other observers have given widely different values to this compression, the ellipticity not being distinguishable by the eye like that of Jupiter.

FRIDAY, 5 OCTOBER, 1877.

Mr. H. C. Russell, F.R.A.S., &c., in the Chair.

Mr. Russell submitted a series of drawings of Mars made by himself, Mr. A. Fairfax, and Mr. G. D. Hirst. These were arranged so as to form a consecutive series of views showing a whole revolution of the planet. Several features were identified on comparison with the drawings of Dawes, but the markings as a whole showed little resemblance to any previous delineation of the planet. Mr. Russell stated that a telegram had been received from Sir G. Airy, the Astronomer Royal, informing him that two satellites to Mars had been discovered at Washington, and requesting a search for the new satellites. Mr. Russell said he had kept a careful watch on Mars with 11⅜-inch refractor, but had not succeeded in seeing them. A discussion took place on some curious facts connected with the thunderstorm of 23rd September, 1877, and the meeting closed.

FRIDAY, 2 NOVEMBER, 1877.

This meeting lapsed, owing to the absence of several of the members from town.

SECTION B.—CHEMISTRY, MINERALOGY, and by amalgamation with Section C, GEOLOGY and PALÆONTOLOGY.

FRIDAY, 18 *MAY*, 1877.

PROFESSOR LIVERSIDGE in the Chair.

THE principal business before the meeting was to elect a new Committee, and to make arrangements for the ensuing year. The following members were elected a Committee, viz.,—PROFESSOR LIVERSIDGE, Chairman; Mr. DIXON, F.C.S., Secretary; and Messrs. SLEEP, MORELL, M'CUTCHEON, and BENSUSAN. It was resolved to make application to the Council for a sum of money for the purchase of a cabinet for the preservation of geological and other specimens collected by the Section and presented to the Society, and for the purchase of standard works of reference upon branches of science embraced by this and the closely allied Sections. A discussion ensued as to the future work of the Section, and Professor Liversidge suggested that excursion parties should be made to visit certain interesting geological sections in the neighbourhood of Sydney. He also proposed that certain members should make a detailed study of the outcrops of the various basaltic dykes (as the one at Bondi) which exist in the vicinity, and should prepare a map of the same; while others should make it their business to plot out the areas of, and the faults in, the Wianamatta shales of the county of Cumberland. Another most interesting object for the investigation of such excursion parties would be to ascertain the extent and general characters of such river drift deposits as that on Lapstone Hill.

Mr. M'CUTCHEON called the attention of the Section to the variable nature of the alloys of Australian gold with silver, and thought that an investigation into the question would be interesting, especially as the quality of certain samples of native gold seems to indicate that deposits have yet to be found in this Colony.

Mr. BENSUSAN exhibited samples of the solid core of hard sandstone and quartzite brought up by the new diamond rock-boring apparatus. He also offered some explanatory remarks upon a series of photographs showing the apparatus at work and the different parts of the same. The meeting then adjourned.

FRIDAY, 15 *JUNE*, 1877.

PROFESSOR LIVERSIDGE in the Chair.

Mr. M'CUTCHEON brought under the notice of the Section a process for the analytic separation of nickel and cobalt, founded on the solubility of sulphide of nickel in cyanide of potassium and the insolubility of sulphide of cobalt.

Mr. SLEEP exhibited specimens of crystallized quartz penetrated by acicular crystals, probably hornblende and crystallized cuprous oxide (cuprite), from Cloncurry mine, encrusted with the *blue* carbonate or chessylite.

Mr. BENSUSAN mentioned having found associated with some specimens of noumeite a considerable quantity of carbonate of bismuth.

FRIDAY, 20 *JULY*, 1877.

PROFESSOR LIVERSIDGE in the Chair.

The CHAIRMAN announced that a sum not exceeding £20 had been placed at the disposal of the Section, for the purchase of a suitable cabinet.

A conversational discussion took place upon chemical and geological subjects, especially relating to work which the Section might undertake.

FRIDAY, 17 *AUGUST*, 1877.

PROFESSOR LIVERSIDGE in the Chair.

PROFESSOR LIVERSIDGE announced that the Hon. F. Lord had invited the members of the Section to examine the Devonian measures near Mount Lambie; and that Mr. P. N. Trebeck had invited them to visit the columnar sandstone at the head of Lane Cove, on days to be subsequently fixed.

Mr. BENSUSAN exhibited a series of interesting silver and copper ores from America, also specimens of cinnabar and other minerals; together with a reputed rhodium ore from Monroe, Orange Co., U.S.

FRIDAY, 21 *SEPTEMBER*, 1877.

PROFESSOR LIVERSIDGE in the Chair.

The CHAIRMAN exhibited a series of specimens of characteristic American minerals, lately received by him from Dr. Forbes, of New York. The collection included examples of many rare and beautiful minerals peculiar to the American continent.

FRIDAY, 19 *OCTOBER*, 1877.

PROFESSOR LIVERSIDGE in the Chair.

The CHAIRMAN showed a specimen of native moss gold, on the artificial formation of which he had read a paper to the Society last session. This specimen occurred on a piece of mispickel from the Uncle Tom claim, Lucknow. He also exhibited a piece of lignite from the Rewa River, Fiji, with the following note attached:—During the time that Mr. Layard, C.M.G., was

Consul in the Fijis, I received from him a small specimen of lignite which he had obtained from the Rewa River. Description: black in colour, the weathered surfaces more or less grey; brittle, breaking with a sub-conchoidal fracture; the fresh surfaces possess a resinous lustre; yields readily to the knife, and furnishes a black powder, and shining streak; it burns readily, but like charcoal almost without flame; no coke is formed, but a voluminous brown-coloured ash is left. Sp. gr. 1·30. Small particles of pyrites are present.

Approximate analysis—

Moisture	16·82
Combustible matter... ...	75·16
Ash...	8·02
	100·00

A second piece yielded only 7·2 per cent. of ash. The portion entered under head of combustible matter includes the sulphur, nitrogen, oxygen, and hydrogen present, which it was not thought necessary to determine until further information was received as to the extent and thickness of the deposit. It is not dissimilar to many lignites used for fuel in Europe.

SATURDAY, 28 *OCTOBER*, 1877.

The members of the Section, on the invitation of Mr. P. N. Trebeck, went to the head of Lane Cove to examine the columnar sandstone which he had brought before the notice of the Society at one of the early meetings of this session.

The columnar structure, in which the individual pieces are of an irregular polygonal form in section, occurs on the top of a hill. It has been formed from the ordinary sandstone, probably by an outflow of basalt or other igneous rock since removed by denudation; the subsequent contraction in cooling causing the mass to form fissures in the lines of least resistance.

FRIDAY, 16 *NOVEMBER*, 1877.

Professor Liversidge in the Chair.

Professor Liversidge exhibited some interesting specimens of the siliceous and other deposits from some of the hot springs in New Zealand. He stated that he was not prepared with any paper descriptive of them, or of the geology of the localities whence they were obtained, for such would take up much more time than he could at present devote to the matter; and moreover, such a paper would perhaps be more or less superfluous,

after the many able descriptions of these springs which had been already published by various observers. He would only trouble them with a few remarks upon certain of the specimens, and would invite their attention to the series of photographs placed on the table, in lieu of any description of the place. Amongst the specimens were some samples of siliceous sinter, from a spring opposite the hotel at Ohaiawai, on the road between the Bay of Islands and Hokianga on the west coast; also of cinnabar, from the mercurial springs near to the same place. Professor Liversidge mentioned that he was much struck by the general similarity between the "volcanic" phenomena at Ohaiawai and those presented by the burning coal seam at Mount Wingen, the so-called "burning mountain," near to Scone—the chief differences being that the phenomena at the latter place are confined to a more limited area, and that water is absent; hence there are no hot springs or pools of warm water at Mount Wingen, as there would be if the jets of steam and heated vapour had to make their upward passage through water. The escaping gases at both places possess very much the same general character, and deposit similar sublimates of sulphur and certain volatile salts around the vents. At the hot mercurial springs near Ohaiawai the mercury occurs both in the native state and in the form of cinnabar; some of the cinnabar is apparently of recent deposition, since it was observed in one place to uniformly and completely fill certain small cracks and crevices existing in the shaly rock, but the greater part of it is evidently mechanically brought to the spot by the small stream which runs down to the lake. The presence of an extensive deposit of coal, shale, or pyrites undergoing a smothered combustion would be quite sufficient to account for the phenomena observed at Ohaiawai and other hot springs in New Zealand—even for the celebrated ones at Ohinemutu and at the Pink and White Terraces on the Lake Rotomahana. Respecting the beautiful bright blue colour of the water in the basins on the Pink and White Terraces at Rotomahana, a blue so extraordinarily beautiful that many travellers are unable to find words to express their admiration for it, Professor Liversidge explained that the blue colour was due to the reflection of the light from the innumerable minute particles of silica suspended in the water—just as the pale sky-blue colour of a mixture of milk and water is caused by the reflection of the light from the minute fat globules suspended in it. He was also inclined to attribute the equally beautiful blue colour of the lower layers of steam floating over the surface of the boiling waters to a similar cause, for he had but little doubt that the escaping steam bears minute particles of silica with it in its upward course. The colour of the steam does not appear to be due to a reflection of the colour of

the water below it, any more than the colour of the water in the basin is due to a reflection of the sky. The beautiful opalescent blue of the water in the basin is very different in appearance from the clear but equally magnificent purple blue of one of *ngwahas* or boiling springs, near Ohinemutu. This latter blue water is remarkably transparent, and one can see down through it to very great depths, but the Terrace water is rendered too turbid by the silica in suspension for the eye to penetrate far down into it. Part of the silica brought up by the water is thrown down as a soft pulverulent deposit at the bottom of the basins, while another portion is more slowly precipitated as a hard and smooth stony material, known as siliceous sinter or geyserite, and it is of this that the terraces and basins are built up. So rapidly is this deposited that leaves and twigs become quickly invested, and it is stated that even dead birds become coated with it before the animal matter has time to decay and fall to pieces. The pink colour of the pink terrace is apparently due to the entanglement by the asperities on the stalactitic faces of the terraces of small quantities of red clay brought down by the water. A specimen of recently formed iron pyrites, which had been taken from a mass now forming upon some dead twigs in one of the hot springs (Jack Loffley's, the Taupo guide) at Lake Taupo, was also shown. On examination, this mass of mixed newly formed iron pyrites and dead vegetable matter was found to contain traces of gold.

SECTION D.—BOTANY.

Four meetings of the Botanic Section have been held this session, at which numerous specimens of indigenous plants have been contributed, identified, named, and placed in the Herbarium which has been established.

A proposition that members of the Section should each make especial study of a separate Order has been adopted, and the following Orders have been undertaken by four of the members:—

Compositæ.	Labeliaceæ.
Epacridaceæ.	Proteaceæ.

SECTION E.—MICROSCOPICAL SCIENCE.

WEDNESDAY, 23 MAY, 1877.

The first meeting of the session was held on the above date.

In the absence of the Chairman, Mr. H. C. Russell, B.A., F.R.C.S., took the Chair.

The following gentlemen were elected as members of the Committee for the current year:—Mr. A. ROBERTS, M.R.C.S. (Chairman), Mr. G. D. HIRST (Secretary), Rev. GEO. MARTIN, Mr. HUGH PATERSON, Dr. MILFORD, and Mr. WM. MACDONNELL.

It was resolved that the future meetings of the Section should be held on the second Monday in each month.

The SECRETARY, on behalf of Mr. H. Sharp, of Adelong, presented to the Society's cabinet a series of twelve slides, consisting chiefly of animal parasites, neatly mounted in glycerine, with tin cells.

A vote of thanks was unanimously accorded to Mr. Sharp.

Mr. G. D. HIRST exhibited Swift's new patent achromatic condenser. He described its construction, and read a few notes on the use of achromatic condensers generally.

Mr. W. MACDONNELL exhibited a metal gauge for measuring thin glass covers to the $\frac{1}{1000}$ inch.

The Rev. GEO. MARTIN exhibited Crouch's No. 1 A binocular microscope, a particularly substantial instrument, with concentric rotating stage, sub-stage, and apparatus.

Dr. MILFORD exhibited a large binocular by Collins, with sub-stage and achromatic condenser added by Gaunt, of Melbourne.

Mr. G. D. HIRST exhibited a prize medal binocular by Swift.

MONDAY, 11 *JUNE*, 1877.

Mr. H. G. A. WRIGHT, M.R.C.S., in the Chair.

The minutes of the preceding meeting were read and confirmed.

Mr. WM. MACDONNELL introduced the subject of the microscopical analysis of drinking water; and a discussion ensued as to the best means of obtaining and preserving sediments for examination.

It was resolved that the matter should be brought before the next meeting.

Mr. G. D. HIRST exhibited Bramhall's illuminator, consisting of a plain mirror introduced beneath the slide on the stage of the microscope. The light being thrown down on the mirror by means of the bull's-eye condenser, is reflected obliquely up through the slide, illuminating the object in its passage; the advantage claimed for this simple piece of apparatus being a resolving power on close-lined tests nearly equal to a large-angled achromatic condenser. In illustration of its power, Mr. Hirst showed a valve of the *N. rhomboides* with the transverse lines, 80,000 to the inch, perfectly resolved under a $\frac{1}{16}$ inch immersion lens.

Mr. WM. MACDONNELL exhibited a Crouch's No. 2A binocular microscope, with a quantity of apparatus. The instrument was furnished with an adaptation, by which perfect centricity of the stage with the optic axis of the tube was easily secured.

Mr. H. PATERSON showed some diatoms he had obtained from the fresh water supplied in the city mains.

MONDAY, 9 *JULY*, 1877.

Mr. ALFRED ROBERTS, M.R.C.S., in the Chair.

A discussion ensued in reference to diatoms obtainable in the vicinity of Sydney, both marine and fresh water species; and the Chairman suggested that members should endeavour to procure and mount specimens for the next meeting, and in doing so should keep notes of the locality and surroundings of each variety, with a view to the ultimate construction of a complete collection of the diatoms of the harbour and its neighbourhood.

Mr. J. U. C. COLYER exhibited specimens of *Drosera peltata*, *Drosera glanduligera*, and *Drosera pygmæa*, insectivorous plants found in the neighbourhood of Sydney. He made some remarks upon the leading characteristics of these species, and promised to pursue the matter further and place the results before the Section in the form of a paper.

Mr. G. D. HIRST showed a drawing of a new species of *Branchionus*—a rotifer apparently common at the present time in ponds on the Sydney water reserve. A specimen was exhibited under the microscope.

Mr. H. G. A. WRIGHT exhibited a patent $\frac{1}{8}$-inch objective by Ross, and as a sample of its resolving powers he showed a valve of the *P. angulatum*, which with the D. eyepiece and illuminated by Ross's $\frac{4}{10}$th inch achromatic condenser was finely resolved into dots. The objective was also tested for penetration on the trachæ of a caterpillar, and was found also to be thoroughly satisfactory in this respect.

The Rev. GEO. MARTIN exhibited some slides of his own preparing, among which were *Foraminifera* from Port Jackson, mounted in damar, and showing well their internal structure; also *Polypide* of *Hydroid zoophyte* from Newcastle, and the parasite *Cimex lectularia;* this latter was prepared in acetic acid, and showed the structure of the thorax and abdominal segments.

Mr. WM. MACDONNELL exhibited a collection of anatomical slides, including blood discs from mammalia, birds, and reptiles, and showing the different size of the corpuscle in each species.

MONDAY, 13 *AUGUST*, 1877.

Mr. ALFRED ROBERTS, M.R.C.S., in the Chair.

THE minutes of the preceding meeting were read and confirmed.

Mr. WM. MACDONNELL exhibited Swift's popular achromatic condenser. He read a few notes descriptive of this piece of apparatus, which combines in itself all the accessories usually adapted to the sub-stage of first-class instruments.

The CHAIRMAN then referring to the proposition made at the last meeting, viz., that members should endeavour to procure and mount specimens of diatoms in the vicinity of Sydney, called upon those who had engaged in this work to report the result.

Mr. H. PATERSON said he had obtained numerous specimens from a pond in the Botanic Gardens, and from the water supplied to the city he exhibited several slides of these.

The Rev. GEO. MARTIN stated that he had examined the mud from anchors of ships in the harbour for marine forms of diatoms, but with poor results; he had, however, obtained specimens of *A. longipes* and *P. angulatum* from scrapings obtained from floating objects. He exhibited a slide showing valves of the *P. angulatum*.

Mr. G. D. HIRST read a paper on "Some local species of *Diatomaceæ*," with an account of the method he recommended to be followed in the preparation of gatherings, and some remarks on the use of diatoms as test objects; he also exhibited numerous slides of the species he had found.

On the motion of Mr. H. G. A. WRIGHT, seconded by Dr. MILFORD, it was resolved that a Committee should be appointed for the classification of local species of diatoms, and the following gentlemen were appointed:—Rev. Geo. Martin, Dr. Morris, Mr. J. U. C. Colyer, Mr. G. D. Hirst.

Dr. MILFORD read a paper on the Coccus of the Cape Mulberry, illustrating the same by drawings of the larva of this parasite in its abdominal and dorsal aspects.

Mr. PERCIVAL PEDLEY exhibited some *Foraminifera* from New Guinea.

MONDAY, 10 *SEPTEMBER*, 1877.

Rev. GEO. MARTIN in the Chair.

The SECRETARY read a note he had received from the Chairman, Mr. Alfred Roberts, apologising for his absence through professional engagements.

Mr. WM. MACDONNELL exhibited two $\frac{1}{50}$ inch objectives, by Seibert. These lenses showed the very finest definition, with a capacity for working through covering glass ·007 inch in thick-

ness; their magnification was 1,600 diameters with the A. eye-piece. A valve of the *N. rhomboides* was shown under one of these objectives resolved into beads.

Mr. MacDonnell also exhibited Crouch's new centering nose-piece, by means of which an objective may be brought into perfect centricity with the revolving stage when the latter is not furnished with any arrangement for effecting this.

Mr. Hugh Paterson exhibited several slides containing local diatoms, principally varieties of the *Pleurosigma.*

Dr. Morris exhibited prepared specimens of the male coccus of the orange, an insect somewhat rare and difficult to procure on account of its diminutive size.

The Rev. George Martin exhibited several slides of pathological subjects, prepared by himself, and subjected to Dr. Beale's staining process.

Mr. P. Pedley exhibited some diatoms from Port Jackson.

TUESDAY, 9 *OCTOBER*, 1877.

Rev. George Martin in the Chair.

Mr. H. Sharp, of Adelong, presented several slides for the cabinet, containing scales of different species of *Podura*, mounted by himself, for which a vote of thanks was accorded.

Mr. H. J. Brown exhibited some specimens of the pink *Synapta*, or Admiralty worm, found by him in Port Jackson. Mr. Brown made a few remarks on the habits of these creatures, the localities in which he had been most successful in finding them, and the method he recommended to be adopted for obtaining and mounting the anchor-shaped spicules. Mr. Brown's remarks were listened to with some interest, as it has not been generally known that the *Synapta* is to be found on this coast.

Mr. H. Sharp read a paper on Zeiss's objectives, with an account of their performance in his hands, by which it appeared from results obtained from some of the most difficult test objects procurable, that these lenses exceeded many of the finest productions of the London makers, in their great resolving power and fine definition. Mr. Sharp, in illustration, showed some difficult diatoms, including the *N. crassinervis*, well resolved with a Zeiss $\frac{1}{18}$-in.

Mr. Wm. MacDonnell read a paper on foreign objectives. He argued that the introduction of high class work, such as these lenses of Zeiss, tended much to remove the prejudice with which many microscopists have hitherto regarded continental objectives, this having arisen from the numerous cheap and inferior glasses which have found their way into the English market. Mr. MacDonnell quoted some extracts showing the haphazard

way in which these cheap lenses are made, and contrasted it with an account of the elaborate and careful manner in which such makers as Zeiss and Seiberz construct their work.

Mr. G. D. Hirst read a paper on "Professor Abbe's Theory of Microscopic Vision," illustrated by experiments with his diffraction platte. Mr. Hirst's paper showed the possibility of misinterpretation when close-lined objects are viewed under high powers, and some novel facts bearing closely on the study of the markings on diatoms were proved by experiments with the diffraction platte.

MONDAY, 12 *NOVEMBER*, 1877.

Mr. Alfred Roberts, M.R.C.S., in the Chair.

The Secretary reported that he had no papers from the members to be read that evening.

The Rev. George Martin read a letter that he had received from the Rev. Mr. Dallinger, the well-known English microscopist, on the choice of objectives of medium power. The letter entered fully into the debated question of angular aperture, and some important information was furnished as to the capabilities of objectives differing widely from each other in this respect.

Dr. Morris exhibited a fine microscope by Browning, on the Stephenson's binocular principle, made specially to his order by this maker. The microscope differed from the ordinary Wenham form in being capable of working as a binocular up to the $\frac{1}{16}$-in. objective with good definition and a well illuminated field. The stage was constructed so as to remain horizontal while the tubes of the microscope incline at a convenient angle for observation. The whole instrument was substantially made, and the finish reflected great credit on the maker.

Professor Liversidge exhibited specimens of "diseased" sugar-cane from the Maryborough districts, Queensland. Professor Liversidge stated that Sir Joseph Hooker, K.C.S.I., Director of the Botanic Gardens, Kew, had written to him for some specimens of the affected canes, as he thought that the "disease" might be somewhat the same as that affecting the coffee plant. By the last mail a reply had been received saying that the specimens had been submitted to careful examination by Mr. Berkeley and Mr. Broom, the two ablest English funglogists, and they had pronounced the markings on the leaves to be due to the presence of a minute fungus, a species of *Depazea*, and the little cup-like bodies under the leaf scrolls which Professor Liversidge had suggested as resembling the fructification of *Æcidiacei* they considered to be due to a coccus.

It was resolved that an application should be made to the Council to obtain if possible the use of the room for the Section once a fortnight during the recess.

Remarks on the Coccus of the Cape Mulberry.

By F. Milford, M.D., M.R.C.S., &c.

[*Read before the Microscopical Section*, 13 *August*, 1877.]

A FEW years ago, in the neighbourhood of Parramatta, I planted a considerable number of mulberry cuttings, three-fourths of which belonged to the Cape variety; the rest were *Morus alba*. These latter have thriven very well, and are now healthy and flourishing. The Cape trees have signally failed, however; they have been stunted in growth, the bark in parts has assumed a black colour, and the foliage has been very scarce. On a casual inspection of the cause I found, some three years since, almost all the Cape trees affected with a parasite having a singular appearance: the tender stalks and young leaves had protuberances on them similar to gall-nuts, raised about from $\frac{1}{30}$ to $\frac{1}{12}$ of an inch above the bark, were dome-shaped, almost circular in circumferance, chocolate-colour, and varied from a line to $\frac{1}{4}$ inch in diameter. These dome-shaped bodies occurred in clusters of about nine or ten each on the affected branch. On removing a specimen from its adhesive surface, I found it contained particles of deep orange-coloured dust, and that the parts of the tree to which it adhered was of a white woolly appearance. Wherever these parasites most abounded the trees seemed most sickly, and accordingly I was desirous of ascertaining their history, in order to procure some means for their destruction, as I could not but connect their sickliness with the presence of these creatures. Accordingly I procured some branches of affected trees, removed one of the dome-shaped bodies, and the dust obtained from it I placed under the microscope, which upon inspection I found to consist of eggs and the larvæ of an insect. I applied to the well-known entomologist Mr. Scott, and having shown him a slide with the objects prepared and a branch of the tree, he at once informed me that it was a coccus, and lent me the 2nd volume of the History of Insects, VIIth of the Family Library, in which is an account of some varieties of European coccus, and recommended me to refer to Cuvier. From reference to these works I have been able to glean the following information with regard to the genus. The protuberances visible on the trees are the female cocci. These dying after impregnation, their eggs and recently hatched larvæ are found in their remains. The eggs at maturity being hatched escape from the dead mother by a small opening or porch at the back and soon change from the larva to the perfect state. The males have wings and are very much smaller than the female. The female, who is furnished with a proboscis, immediately takes up a position on the tree and inserts the tube into the bark, through which she extracts the nutrient juices; here she remains stationary. The male when at liberty

does not use his wings, but walks up to the female and remains with her. After fecundation the female deposits her eggs between the tree and herself, having exhausted the whole of her substance in generating the ova; she then dies and becomes a covering for the eggs, which in their turn go through the same course of existence. I have here views of the larva in its abdominal and dorsal aspects and the egg magnified 190 diameters, also a branch of the mulberry and a slide showing the larva. These creatures attack some species of fern, but will leave others in immediate juxtaposition in our ferneries.

Various efforts have been made to get rid of this pest from the trees without beneficial results, and I hear that the farmers in the neighbourhood of Baulkham Hills use soft soap and sulphur for the purpose freely applied. I propose trying some experiments for the purpose of destroying them.

Cuvier describes four varieties of these creatures, the third family of the *Homopterus hemiptera* called *Gallinsecta*. He says that they have only a single joint in the tarsis with a single hook at the tip. The male is destitute of a proboscis, has only two wings, which shut horizontally upon the body: the abdomen is terminated by two threads. The female is without wings, and furnished with a proboscis. The antennæ are filiform and often eleven-jointed. The four varieties mentioned by Cuvier, *C. admidem*, *C. cacti*, *C. palmicas*, *C. ghüs*.

These creatures here depicted have a single joint in the tarsi, but they have three hooks at the tip. I have never been able to capture a specimen of the perfect winged male. These differ materially from the species of the coccus which attacks the orange, which I have also examined microscopically.

Notes on some local Species of Diatomaceæ.

By G. D. Hirst.

[*Read before the Microscopical Section*, 13 *August*, 1877.]

At the last meeting of this Section it was suggested by our Chairman that, as probably many marine and fresh water species of *Diatomaceæ* existed in the vicinity of this city, on the observation and classifying of which but little had been hitherto done, it would be interesting and also doing good work if such of the members as were able, would devote a little time to obtaining and preparing specimens for our meeting to-night. Pressure of business has prevented me until the last week or ten days from taking the matter up, and this must be my apology for the somewhat hurried character of these notes, which I will ask you to look upon as the merest outline of what might be done by one having more time and talent than I possess to devote to this very interesting branch of microscopical research. There is in almost every department of Natural History on this continent such a vast field for work, so much unexplored territory, such an abundant harvest waiting only to be gathered, that the amateur, conscious of his own feeble powers, feels inclined to despair, from the feeling perhaps of not knowing where to begin. The *Diatomaceæ* are no exception to this rule; little or no work has yet been done to classify the very numerous species which may be found within a mile of Sydney, and I have been much embarrassed sometimes in trying to identify specimens with any drawing or description in the standard works on the subject.

Many well-known European species have their representatives in these waters, but there are many more whose designation one hesitates to fix from the want of some work in which these Australian varieties have been included. Commencing first with marine and brackish water species, my first gathering was from some stranded logs in Darling Harbour that looked promising, that is to say green and muddy, but after careful washing and preparation the result turned out absolutely nil, not a single diatom rewarded my search; however, as the locality looked so very favourable I determined to try again, and a few hundred yards further up the bay I obtained scrapings from some of the logs that had evidently been in the water for a considerable time, being covered on their under surface with a thick brown scum. This on being treated yielded a fair supply of various forms, prominent among which was *Pleurosigma Balticum*, valves rather smaller than the English species, but the cross-lines coarser; I measured them 34,000 to the inch. Prichard in his Infusoria gives 38,000 as the average for English and Continental species. The following were also in tolerable abundance in the same gathering:—*Pleurosigma elongatum*, diagonal lines 57,000 to the

inch, being finer than English specimens, which average 48,000. Two or three species of *Stauroneis* were also found, on one of which the markings though coarse were so faint that nothing lower than the $\frac{1}{16}$-in. with careful illumination would show them; also a magnificent *Navicula*, with coarse beading easily resolvable under the 1-in., a really beautiful diatom, and one that I have been unable to identify with any known species; also a species of *Nitzschia*, very like the *Nitzschia Brightwellii* in form and size; but, instead of possessing coarse beading like this diatom, its markings if any were so fine as to defy the resolving power of my $\frac{1}{16}$-in. immersion of large angle. I have no doubt that the lines existed, though I could not see them, as some of these *Nitzschia* are among the most difficult of our test objects. Also *Pleurosigma*, probably *Æsturii;* diagonal lines faint, and in consequence difficult to measure accurately, but about 65,000 to the inch, and a good test for a large-angled $\frac{1}{4}$-inch. A few valves were also found of a curious form of *Pleurosigma*, very broad with obtuse ends, and totally devoid of any markings whatever, as far as I could ascertain with any power to the $\frac{1}{16}$-in. The species most plentiful in these Darling Harbour gatherings appear to be the *Balticum* and two or three kinds of *Stauroneis;* the latter is a very elegant genus, deriving its name from its having the central nodule prolonged into a pellucid band or stauros free from striæ. The different species found of this genus vary much in size, some are as large as 150″, while others are no more than 800″; this last is far however from being the smallest variety known, as Prichard mentions some as small as 1,600″. Doubtless other parts of Darling Harbour will furnish numerous other species of diatoms, but I can only mention this result of one gathering.

The mud near the mouth of Cook's River will, if collected from suitable spots, yield a rich return. From a sample supplied me by Dr. Tucker I have several slides on which are the following:—*Pleurosigma formosum*, diagonal lines 33,000 to the inch. Pritchard gives for English specimens 36,000; *Pleurosigma Balticum*, small valves, but like the Darling Harbour specimens much coarser marked than the old world species, the striæ ranging as low as 28,000 to the inch. *Pleurosigma Æsturii* and several species of *Cymbella* were also numerous. I would strongly recommend this locality to any one collecting diatoms, as I am certain that there would be found a rich harvest of interesting forms both of known and unknown species.

It appears to me however, that it is in fresh water that the greatest variety of our local *Diatomaceæ* are to be found. My first trial for fresh water specimens was in the sediment obtained from the top of a filter supplied with water from the city main. This yielded a large supply of diatoms, and sponge spiculæ,

probably from fresh water sponges growing in the dams; amongst the diatoms were an immense multitude of minute diamond-shaped bodies not more than the 2,000th of an inch in extreme length; some with two holes pierced in them near the centre, others without. I have been unable to find anything resembling them in any work I have access to; they may probably be a species of minute diatom, but whatever be their nature, they are undoubtedly present in vast numbers in the water supplied to the city. Of the known species of diatoms in this gathering, I found *Pinnularia* both *major* and *nobilis*, *Stauroneis*, *Cymbella*, and several kinds of *Pleurosigma*. The sponge spicules mentioned were present in great abundance; under the microscope they look most unpleasantly indigestible, having sharply pointed ends and jagged edges. One could not but after seeing them register a mental vow never to drink anything but filtered water.

At the head of Fletcher's bay, a small rocky bight south of Bondi, there is a stream in which I obtained a plentiful supply of *Synedra fulgens*, a long spindle-shaped diatom with coarse transverse ribbing; the gathering was very pure and free from extraneous matter, but the most plentiful haul I have had was from a fresh-water pool on the old tramway track leading to Bondi beach. I find the limit of this paper will not allow me to enter into a full account of the extraordinary number of species and different genus contained in this gathering; besides, the time at my disposal has not afforded me an opportunity of identifying half of them. I will merely mention *Pinnularia major* and *nobilis*, besides several other species of this genus, *Cymbella*, several forms of *Naviculæ* in abundance, and *Stauroneis* of all kinds, to give you an idea of the variety to be met with on a single slide. That you may the more easily judge for yourselves of the abundance in which so many different species are present, I have prepared a few slides for presentation to any gentleman who may wish to have one. One thing I notice in this gathering, that amid the multiplicity of other forms the *Pleurosigma* are conspicuous by their absence; at least, in a hasty search through several slides I have not been able to find any.

A peculiarity that seems connected with the *Diatomaceæ* in the vicinity of Sydney, so far as my limited experience goes, is the variety of genera met with in a single gathering; in England and on the Continent, gatherings taken from different places yield each a characteristic genus or even a single species. *Pleurosigma angulatum*, *P. Balticum*, *Pinnularia*, are found with scarcely the intervention of a valve of another species; here we seem to have a sort of happy family, which, though gratifying to those who seek variety on their slides, is rather puzzling to the collector who wishes perhaps to adapt his slides and style of mounting to suit the conditions required for the perfect display of any given diatom.

It may not be out of place here if I mention the process I adopt for cleaning the diatom valves, and freeing them from the extraneous matter, which even in the purest gatherings is sure to be present, and which I have found out of several methods tried to be the most simple and efficacious. Of course the process of cleaning will in some instances have to be modified by the peculiar nature of the matter in which the diatoms are contained, but the following will answer very well for any of the ordinary fresh or salt water gatherings obtainable in this vicinity. The apparatus required will be a couple of Florence flasks, a spirit lamp, a small quantity of chlorate of potash, and some nitric and sulphuric acid. Place the gathering in one of the Florence flasks, half-fill with water, and shake well for a couple of minutes; this will detatch the diatoms from the vegetable and flocculent matter to which they adhere; after shaking, hold the flask upright for eight or ten seconds, when the particles of sand will subside to the bottom, now before the diatoms have time to settle also, decant the liquid into the other flask; this process might be repeated with advantage once or twice, when one troublesome element, that is the sand, will have been pretty well got rid of.

After the final decanting let the liquid stand for half-an-hour, giving everything plenty of time to settle, carefully pour off the water without disturbing the sediment, and add nitric acid until the flask is about one-third full; this must now be boiled over the spirit lamp for ten minutes or so, then allowing the deposit to settle as before, pour off the acid and add fresh, boil again, and again pour off the liquid after giving the deposit full time to settle. If there is any lime in the gathering this must be got rid of by the addition of hydrochloric acid; a little of this acid added will immediately show its presence by effervescing; if there is no lime, sulphuric acid can now be added in about the same quantity as the nitric; this must be boiled until it fails to turn any darker; if there is much carbonaceous matter in the gathering the mixture will turn quite black. While the acid is on the boiling point add cautiously in very small portions at a time, to prevent any chance of explosion, some powdered chlorate of potass; the liquid will gradually turn lighter and eventually quite clear, the diatoms being suspended in it in the form of white cloudy flocculent matter. When the acid is cool add cautiously water until the flask is three parts full, allow the diatoms ample time to settle, as the acid on account of its high specific gravity keeps them suspended for a longer time than water alone; when they have at last settled pour off and add more water, repeating the process until the diatoms are washed clean from the acid, which will be when the liquid poured off gives no acid taste when applied to the tongue.

The diatoms may now be transferred to a convenient receptacle and preserved in distilled water until required; a drop or two of methylated spirit added will prevent the chance of any confervoid growths. The above process may sound somewhat formidable to those not experienced, but it practically is not troublesome, and will be sure to give good results if carefully carried out. I have here two bottles, in one of which is the *raw material* if I may so term it, and the other contains the pure diatoms obtained from a similar quantity of stuff. You will see there is a large reduction in bulk, showing the amount of foreign matter got rid of.

In mounting the diatoms, some are better shown in balsam or damar, others display their markings best when dry. The general rule appears to be as far as my experience goes, that all those species with coarse lines or beadings show to the best advantage when mounted in balsam; those with very fine lines, such as in all the difficult test objects, are better mounted dry.

In conclusion I would say a word in reply to questions I have heard put sometimes, when after the expenditure of much time, trouble, and patience, adjusting of light and mirror, the lines on some difficult test diatom have at last been fairly displayed, well what good have you accomplished? In what respect is microscopic science benefited by the fact that such a diatom has so many lines to the inch? There are I know many microscopists who affect to despise those whom they call "Diatomaniacs" and count the time and trouble expended in the resolution of markings as simply wasted. Now without for a moment arguing that the only or chief work for the microscope is counting the striæ on diatoms, I would hold that the time spent in successfully resolving a difficult test is by no means wasted. The tyro sitting down before his newly acquired instrument places an object on the stage, turns on the full glare of light from his mirror and condenser and fancies he sees everything to perfection. Let him try the same method of proceeding on some delicate diatom valve; and where in the hand of the skilful manipulator a moment before, lines or beading were beautifully displayed, he sees a blank. He may spend long hours in trying every trick of illumination, moderating his light, varying its obliquity by altering the angle of his mirror, focussing and re-focussing the condenser, altering the adjustment of his objective, and at last when his patience is well nigh exhausted the desired result is obtained, the delicate markings start suddenly into view, and he possesses the consciousness that under his hands mirror, condenser, and objective are now doing their best. Has this time been wasted? I think not; he will carry the knowledge obtained in the struggle and apply it in the broad field of real work that lies before him on every side. Should he turn his attention to the

development of minute life, organs are seen in living transparent bodies where before he saw nothing; should he be a pathologist, tissues appear full of structure which before in his inexperienced hands seemed homogeneous, minute nerve fibres become visible where before they were unsuspected. I do not think I am exaggerating in saying what I have; I have felt the benefit conveyed in an education of this kind, and I could recommend nothing better for a beginner than a year's constant study of all the species of *Diatomaceæ* at his command. When he is fully convinced that he sees all in them that his optical means will allow, he is far better fitted to commence real work than he ever could have been without this preliminary training. Only let us not mistake: our work, though commencing on diatoms, should not end there; let their delicate lines be the means of familiarizing ourselves with the optical capabilities of the noble instruments at our disposal, and the questions I have quoted will be duly answered—the time spent will not be in vain.

SECTION F.—GEOGRAPHY AND ETHNOLOGY.

THIS being the first meeting of the Section for the present year, the office-bearers were elected to serve on the Committee: The Hon. LEOPOLD FANE DE SALIS, M.L.C., Messrs. E. DU FAUR, F.R.G.S., WILLIAM FORDE, H. A. GILLIAT, JAMES MANNING, and E. L. MONTEFIORE, out of which number Mr. DU FAUR was elected Chairman, and Mr. W. FORDE Hon. Secretary. The CHAIRMAN reported the general objects of the Section and the progress made during the past session, and Mr. Forde read some remarks which he had prepared on various geographical subjects, to which the attention of members was specially directed. With a view of keeping a record of what may appear from time to time in local or other papers relating to geographical exploration in all parts of the world, members were invited to assist the Committee in making such a collection as complete as possible; and clippings from European and foreign papers on this subject will be gladly received. Attention of members was called to an interesting private expedition to New Britain and New Guinea which recently left Sydney. It was suggested that much information might be collected from surveyors who have been more recently extending their work into that portion of the north-western district of this Colony, of which at present little is known.

SECTION G.—LITERATURE AND THE FINE ARTS.

[No report of meetings of this Section has been sent in.]

SECTION H.—MEDICAL SCIENCE.

During the session of 1877 there have been held eight meetings of the Section—one special general meeting for the election of office-bearers, and seven general meetings.

The following gentlemen were elected members of the Committee for the current year.

J. C. Neild, Chairman.
F. N. Milford,
H. G. A. Wright,
R. Schuette,
W. J. O'Reilly, } members of Committee.
P. S. Jones,
H. N. MacLaurin, } Secretaries.

At the meetings many papers of considerable interest were read by members of the Society, and most of the meetings of the Section were well attended.

The papers read being of an exclusively professional character, the Committee do not recommend that any of them should be published in the Journal of the Royal Society.

P. SYDNEY JONES.
Nov. 27th, 1877. H. N. MACLAURIN.

SECTION I.—SANITARY SCIENCE.

Report of the Social and Sanitary Science Section of Royal Society for the session of 1877.

Sydney, 4 December, 1877.

To the President of the Royal Society of New South Wales.

Sir,

I have the honor to submit the following report:—

The Section held its first meeting on the 21st day of March last, when the gentlemen were elected to the offices named.

Mr. Alfred Roberts, Chairman.
Messrs. Jackson, Bedford, Belgrave, and Murray, members of Committee.
Mr. Harrie Wood, Honorary Secretary.

On the subject of the Vital Statistics of the Colony further information was obtained from the Registrar General.

Steps were taken to procure the Report of the Royal College of Physicians on the "Improvement of Health of Towns, 1849 to 1869," Report on "Cellar Dwellings and Common Lodging-houses," Report on Model Lodging-houses. Rumeig (H. W.), "Public Health, the right use of records founded on local facts."

The Chairman was asked to read the paper which he had prepared on the Leirneur system of Sewage, before the Society, on account of its public importance.

On the 16th July last, Mr. Jackson read an able paper on Small-pox in its hygienic aspect.

Some of the recent meetings of the Section lapsed for want of a quorum, owing to the inability of members to attend.

I have, &c.,

ALFRED ROBERTS,

Chairman.

APPENDIX.

ABSTRACT OF THE METEOROLOGICAL OBSERVATIONS TAKEN AT THE SYDNEY OBSERVATORY.

LATITUDE 33° 51′ 41″ ; LONGITUDE 10h 4m 46s ; MAGNETIC VARIATION 9° 32′ 45″ East.

JANUARY, 1877.—GENERAL ABSTRACT.

Barometer ... At 32° Faht.	Highest Reading	30·066 inches on the 28th, at 9·30 a.m.	
	Lowest Reading	29·357 „ on the 11th, at 12 noon.	
	Mean Height	29·717	

(Being 0·051 inch less than that in the same month on an average of the preceding 18 years.)

Wind ...	Greatest Pressure	8·4 lbs. on the 29th.	
	Mean Pressure	0·6 lb.	
	Number of Days Calm ...	0	
	Prevailing Direction ...	S.	

(Prevailing direction during the same month for the preceding 18 years N.E.)

Temperature	Highest in the Shade ...	93·8	On the 6th.
	Lowest in the Shade ...	57·8	On the 14th.
	Greatest Range	23·9	On the 6th.
	Highest in the Sun ...	149·2	On the 6th.
	Highest in Black Box with Glass Top	203·1	On the 10th.
	Lowest on the Grass ...	55·3	On the 29th.
	Mean Diurnal Range ...	12·6	
	Mean in the Shade... ...	72·0	

(Being 0·8 greater than that of the same month on an average of the preceding 18 years.)

Humidity ...	Greatest Amount	96·0	On the 8th.
	Least	41·0	On the 6th.
	Mean	71·7	

(Being 1·1 less than that of the same month on an average of the preceding 18 years.)

Rain ...	Number of Days	10	
	Greatest Fall	0·840 inch.	On the 12th.
	Total Fall	1·104 inch.	65 feet above ground.
		1·550 inch.	15 in. above ground.

(Being 2·352 inches less than that of the same month on an average of the preceding 18 years.)

Evaporation	Total Amount	6·811 inches.
Ozone ...	Mean Amount	6·4

(Being 1·8 greater than that in the same month on an average of the preceding 17 years.)

Electricity...	Number of Days Lightning	3
Cloudy Sky...	Mean Amount	7·0
	Number of Clear Days ...	1
Meteors ...	Number Observed	1

Remarks.

The severe drought still continues in the western and south-western districts, but along the coast and in New England some rain has fallen. In Sydney the temperature has been high, and the rainfall 2·352 inches below the average, and rain is very much wanted.

GOVERNMENT OBSERVATORY, SYDNEY.

LATITUDE 33° 51′ 41″; LONGITUDE 10h 4m 46s; MAGNETIC VARIATION 9° 32′ 45″ East.

FEBRUARY, 1877.—GENERAL ABSTRACT.

Barometer ... At 32° Faht.	Highest Reading	30·139 inches on the 3rd, at 8·10 p.m
	Lowest Reading	39·567 „ on the 22nd, at 6 p.m
	Mean Height	29·850

(Being 0·052 inch greater than that in the same month on an average of the preceding 18 years.)

Wind ...	Greatest Pressure	11·5 lbs. on the 23rd.
	Mean Pressure	0·7 lb.
	Number of Days Calm ...	0
	Prevailing Direction ...	S.

(Prevailing direction during the same month for the preceding 18 years S.)

Temperature	Highest in the Shade ...	90·0	On the 1st.
	Lowest in the Shade ...	58·2	On the 3rd.
	Greatest Range	19·4	On the 16th.
	Highest in the Sun ...	151·9	On the 1st.
	Highest in Black Box with Glass Top	200·1	On the 1st.
	Lowest on the Grass ...	52·7	On the 9th.
	Mean Diurnal Range ...	12·8	
	Mean in the Shade ...	72·3	

(Being 1·6 greater than that of the same month on an average of the preceding 18 years.)

Humidity ...	Greatest Amount	99·0	On the 24th.
	Least	42·0	On the 9th.
	Mean	71·7	

(Being 3·2 less than that of the same month on an average of the preceding 18 years.)

Rain ...	Number of Days	10 rain and 5 dew.	
	Greatest Fall	0·609 inch.	On the 24th.
	Total Fall	0·853 inch.	65 feet above ground.
		1·600 inch.	15 in. above ground.

(Being 4·922 inches less than that of the same month on an average of the preceding 18 years.)

Evaporation	Total Amount	5·848 inches.
Ozone ...	Mean Amount	6·3

(Being 1·6 greater than that in the same month on an average of the preceding 17 years.)

Electricity...	Number of Days Lightning	6
Cloudy Sky...	Mean Amount	6·8
	Number of Clear Days ...	1
Meteors ...	Number Observed	2

Remarks.

Another hot and very dry month; at thirty-two of the stations the rainfall was less than one inch. At Sydney the temperature was 1·6 greater than the average, and the rainfall 4·922 inches below the average of the last 18 years. Inland the continued drought is severely felt, and great numbers of sheep and cattle are dying.

GOVERNMENT OBSERVATORY, SYDNEY.

LATITUDE 33° 51′ 41″ ; LONGITUDE 10h 4m 46s ; MAGNETIC VARIATION 9° 32′ 45″ East.

MARCH, 1877.—GENERAL ABSTRACT.

Barometer ... At 32° Faht.	Highest Reading	30·187 inches on the 31st, at 8 a.m.
	Lowest Reading	29·579 „ on the 2nd, at 5 p.m.
	Mean Height	29·961 „

(Being 0·061 inch greater than that in the same month on an average of the preceding 18 years.)

Wind ...	Greatest Pressure... ...	11·5 lbs. on the 2nd.
	Mean Pressure	0·6 lb.
	Number of Days Calm ...	0
	Prevailing Direction ...	N.E.

(Prevailing direction during the same month for the preceding 18 years N.E.)

Temperature	Highest in the Shade ...	90·9	... On the 1st.
	Lowest in the Shade ...	59·5	... On the 8th.
	Greatest Range	17·7	... On the 15th.
	Highest in the Sun ...	150·3	... On the 1st.
	Highest in Black Box with Glass Top	188·3	... On the 1st.
	Lowest on the Grass ...	53·5	... On the 4th.
	Mean Diurnal Range ...	11·2	
	Mean in the Shade ...	69·9	

(Being 0·7 greater than that of the same month on an average of the preceding 18 years.)

Humidity ...	Greatest Amount ...	99·0	... On the 17th.
	Least	49·0	... On the 4th.
	Mean	79·3	

(Being 3·0 greater than that of the same month on an average of the preceding 18 years.)

Rain	Number of Days	17 rain and 3 dew.	
	Greatest Fall	2·495 inches.	On the 31st.
	Total Fall	5·617 inches.	65 ft. above ground.
		6·343 inches.	15 in. above ground.

(Being 0·903 inch greater than that of the same month on an average of the preceding 18 years.)

Evaporation	Total Amount	4·228 inches.
Ozone ...	Mean Amount	5·7

(Being 0·7 greater than that in the same month on an average of the preceding 17 years.)

Electricity...	Number of Days Lightning	11
Cloudy Sky...	Mean Amount	6·4
	Number of Clear Days ...	1
Meteors ...	Number Observed ...	2

Remarks.

Valuable rains have fallen along the coast and mountain districts ; but in the districts about Mudgee, Dubbo, and thence westward, the drought still continues. At Sydney, the rainfall, the temperature, and the barometer have all been above the average.

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GOVERNMENT OBSERVATORY, SYDNEY.

LATITUDE 33° 51′ 41″; LONGITUDE 10h 4m 46s; MAGNETIC VARIATION 9° 32′ 45″ East.

APRIL, 1877.—GENERAL ABSTRACT.

Barometer ... At 32° Faht.	Highest Reading	30·293 inches on the 15th, at 10 a.m.
	Lowest Reading	29·515 ,, on the 26th, at 1 p.m.
	Mean Height	29·948

(Being 0·024 inch greater than that in the same month on an average of the preceding 18 years.)

Wind ...	Greatest Pressure	14·6 lbs. on the 26th.
	Mean Pressure	0·6 lb.
	Number of Days Calm ...	0
	Prevailing Direction ...	W.

(Prevailing direction during the same month for the preceding 18 years W.)

Temperature	Highest in the Shade ...	83·7	On the 10th.
	Lowest in the Shade ...	48·6	On the 24th.
	Greatest Range	21·1	On the 10th.
	Highest in the Sun ...	144·1	On the 10th.
	Highest in Black Box with Glass Top	186·5	On the 10th.
	Lowest on the Grass ...	44·6	On the 27th.
	Mean Diurnal Range ...	13·7	
	Mean in the Shade... ...	64·7	

(Being 0·3 less than that of the same month on an average of the preceding 18 years.)

Humidity ...	Greatest Amount	100·0	On the 29th.
	Least	38·0	On the 27th.
	Mean	72·2	

(Being 5·6 less than that of the same month on an average of the preceding 18 years.)

Rain ...	Number of Days	6 rain and 8 dew.	
	Greatest Fall	3·752 inches.	On the 30th.
	Total Fall	5·550 inches.	65 feet above ground.
		6·572 inches.	15 in. above ground.

(Being 0·665 inch less than that of the same month on an average of the preceding 18 years.)

Evaporation	Total Amount	3·855 inches.
Ozone ...	Mean Amount	6·7

(Being 1·6 greater than that in the same month on an average of the preceding 17 years.)

Electricity...	Number of Days Lightning	7
Cloudy Sky	Mean Amount	4·1
	Number of Clear Days ...	0
Meteors ...	Number Observed	2

Remarks.

Temperature this month is rather below the average at Sydney. Along the coast, between Bodalla and Newcastle, and extending inland to the mountains, fine rains have again fallen; but in other parts of the Colony the fall has been very small, and the rivers Darling and Murray are very low and still falling.

GOVERNMENT OBSERVATORY, SYDNEY.

LATITUDE 33° 51′ 41″; LONGITUDE 10h 4m 46s; MAGNETIC VARIATION 9° 32′ 45″ East.

MAY, 1877.—GENERAL ABSTRACT.

Barometer ... At 32° Faht.	Highest Reading	30·308	inches on the 31st, at 10 a.m.
	Lowest Reading	29·201	„ on the 23rd, at 5 p.m.
	Mean Height	29·724	

(Being 0·207 inch less than that in the same month on an average of the preceding 18 years.)

Wind ...	Greatest Pressure... ...	162·0 lbs. on the 23rd.	
	Mean Pressure	1·1 lb.	
	Number of Days Calm ...	0	
	Prevailing Direction ...	W.	

(Prevailing direction during the same month for the preceding 18 years W.)

Temperature	Highest in the Shade ...	72·3	... On the 22nd and 23rd.
	Lowest in the Shade ...	46·7	... On the 21st and 28th.
	Greatest Range	21·5	... On the 22nd.
	Highest in the Sun ...	127·1	... On the 6th.
	Highest in Black Box with Glass Top	142·2	... On the 24th.
	Lowest on the Grass ...	41·3	... On the 27th.
	Mean Diurnal Range ...	11·7	
	Mean in the Shade ...	59·4	

(Being 0·9 greater than that of the same month on an average of the preceding 18 years.)

Humidity ...	Greatest Amount... ...	100·0	... On the 1st, 14th, and 15th.
	Least	36·0	... On the 24th.
	Mean	74·6	

(Being 1·6 less than that of the same month on an average of the preceding 18 years.)

Rain... ...	Number of Days	16	
	Greatest Fall	3·483 inches.	On the 2nd.
	Total Fall	6·749 inches.	65 ft. above ground.
		9·945 inches.	15 in. above ground.

(Being 4·830 inches greater than that of the same month on an average of the preceding 18 years.)

Evaporation	Total Amount	2·776 inches.	
Ozone ...	Mean Amount	6·7	

(Being 1·9 greater than that in the same month on an average of the preceding 17 years.)

Electricity...	Number of Days Lightning	9
Cloudy Sky	Mean Amount	5·7
	Number of Clear Days ...	0
Meteors ...	Number Observed ...	0

Remarks.

The barometer this month is considerably below the average, and the temperature is above it. Abundant rains have fallen on all the coast and mountain districts. The amount at Liverpool was over eleven inches, and at several stations over ten inches; but little or none has fallen in the west, and the rivers Darling and Murray are very low and falling. Tidal waves reached Sydney at 5h. 20m. a.m. of the 11th May, and continued all day; the height of the greatest was 3 ft. 6 in. They were observed at other points along our coast, and were much larger in New Zealand.

GOVERNMENT OBSERVATORY, SYDNEY.

LATITUDE 33° 51′ 41″; LONGITUDE $10^h\ 4^m\ 46^s$; MAGNETIC VARIATION 9° 32′ 45″ East.

JUNE, 1877.—GENERAL ABSTRACT.

Barometer ... At 32° Faht.	Highest Reading ...	... 30·473 inches on the 19th, at 10 a.m.
	Lowest Reading ...	... 29·780 „ on the 12th, at 5 a.m.
	Mean Height ...	... 30·117

(Being 0·196 inch greater than that in the same month on an average of the preceding 18 years.)

Wind ...	Greatest Pressure ...	... 14·6 lbs. on the 27th.
	Mean Pressure ...	... 0·5 lb.
	Number of Days Calm	... 0
	Prevailing Direction	... W.

(Prevailing direction during the same month for the preceding 18 years W.)

Temperature	Highest in the Shade	... 68·9 on the 8th.
	Lowest in the Shade	... 41·6 on the 29th.
	Greatest Range ...	... 22·6 on the 20th.
	Highest in the Sun	...121·0 on the 5th.
	Highest in Black Box with Glass Top ...	...138·3 on the 6th.
	Lowest on the Grass	... 37·3 on the 29th.
	Mean Diurnal Range	... 14·0
	Mean in the Shade...	... 54·9

(Being 0·1 greater than that of the same month on an average of the preceding 18 years.)

Humidity ...	Greatest Amount ...	...100·0 on the 4th, 5th, 25th, and 26th.
	Least	... 42·0 on the 20th.
	Mean	... 77·9

(Being 0·8 greater than that of the same month on an average of the preceding 18 years.)

Rain... ...	Number of Days ...	... 5 rain and 13 dew.
	Greatest Fall ..	... 0·288 inch. On the 12th.
	Total Fall	... { 0·670* inch. 65 feet above ground. 0·541 inch. 15 inches above ground.

(Being 5·254 inches less than that of the same month on an average of the preceding 18 years.)

Evaporation	Total Amount ...	... 1·959 inch.
Ozone ...	Mean Amount ...	... 4·1 „

(Being 1·4 less than that in the same month on an average of the preceding 18 years.)

Electricity...	Number of Days Lightning	3
Cloudy Sky...	Mean Amount ...	... 3·6
	Number of Clear Days	... 3
Meteors ...	Number Observed ...	... 0

* To midnight, June 30th.

Remarks.

Mean Barometer is this month 0·196 greater than the average, and the temperature very close to the average. Generally the month has been very dry, except the district about the head of the Murray River, where fine rains have fallen, and at the end of the month the Murray at Wentworth was 9 ft. 9 in. above summer level and rising, while the Darling is still below summer level.

GOVERNMENT OBSERVATORY, SYDNEY.

LATITUDE 33° 51′ 41″; LONGITUDE 10h 4m 46s; MAGNETIC VARIATION 9° 32′ 45″ East.

JULY, 1877.—GENERAL ABSTRACT.

Barometer .. At 32° Faht.	Highest Reading ...	30·508 inches on the 3rd, at 9 a.m.	
	Lowest Reading	29·510 „ on the 18th, at 3 p.m.	
	Mean Height	30·075	

(Being 0·137 inch greater than that in the same month on an average of the preceding 18 years.)

Wind ...	Greatest Pressure ...	19·8 lbs. on the 15th.	
	Mean Pressure	0·6 lb.	
	Number of Days Calm ...	0	
	Prevailing Direction ...	W.	

(Prevailing direction during the same month for the preceding 18 years W.N.W.)

Temperature	Highest in the Shade ...	66·1	... On the 9th.
	Lowest in the Shade ...	45·6	... On the 23rd.
	Greatest Range	16·2	... On the 31st.
	Highest in the Sun ...	124·7	... On the 19th.
	Highest in Black Box with Glass Top	135·2	... On the 31st.
	Lowest on the Grass ...	39·8	... On the 27th.
	Mean Diurnal Range ...	11·3	
	Mean in the Shade ...	54·9	

(Being 2·6 greater than that of the same month on an average of the preceding 18 years.)

Humidity ...	Greatest Amount ...	100·0	...On the 1st, 2nd, 11th, 12th, 13th, 14th, 15th, 16th, and 31st.
	Least	50·0	...On the 28th.
	Mean	85·2	

(Being 11·0 greater than that of the same month on an average of the preceding 18 years.)

Rain	Number of Days ...	17 rain and 4 dew.	
	Greatest Fall	3·109 inches.	On the 15th.
	Total Fall	7·053 inches.	65 ft. above ground.
		11·410 inches.	15 in. above ground.

(Being 7·126 inches greater than that of the same month on an average of the preceding 18 years.)

Evaporation	Total Amount	1·752 inch.
Ozone ...	Mean Amount	5·9

(Being 0·6 greater than that in the same month on an average of the preceding 16 years.)

Electricity ...	Number of Days Lightning	5
Cloudy Sky	Mean Amount	5·9
	Number of Clear Days ...	1
Meteors ...	Number Observed ...	2

Remarks.

The Barometer has been much above the average, and the weather unusually mild for the season; the temperature being 2·6 above the average. Very heavy rains fell along the coast only, from Bodalla to Clarence River; the fall was heaviest on the coast near Sydney, the greatest amount recorded being 12·180 inches at Gosford. At the Heads of the Murray River the rains extended a little over the main range of mountains, and at Wentworth the river was 11 feet above summer level; at the same time and place the river Darling was very low.

GOVERNMENT OBSERVATORY, SYDNEY.

LATITUDE 33° 51′ 41″; LONGITUDE 10h 4m 46s; MAGNETIC VARIATION 9° 25′ 2″ East.

AUGUST, 1877.—GENERAL ABSTRACT.

Barometer ... At 32° Faht.	Highest Reading	30·350 inches on the 7th, at 8 a.m.	
	Lowest Reading	29·611 „ on the 25th, at 2 p.m.	
	Mean Height	30·009	

(Being 0·065 inch greater than that in the same month on an average of the preceding 18 years.)

Wind ...	Greatest Pressure	18·6 lbs. on the 10th.	
	Mean Pressure	0·5 lb.	
	Number of Days Calm ...	0	
	Prevailing Direction ...	W.	

(Prevailing direction during the same month for the preceding 18 years W.)

Temperature	Highest in the Shade ...	74·3	On the 15th.
	Lowest in the Shade ...	44·9	On the 3rd.
	Greatest Range	26·0	On the 14th.
	Highest in the Sun ...	130·0	On the 27th.
	Highest in Black Box with Glass Top	153·4	On the 24th.
	Lowest on the Grass ...	37·9	On the 23rd.
	Mean Diurnal Range ...	16·3	
	Mean in the Shade ...	56·3	

(Being 1·8 greater than that of the same month on an average of the preceding 18 years.)

Humidity ...	Greatest Amount	99·0	On the 1st.
	Least	35·0	On the 15th.
	Mean	71·3	

(Being 0·7 greater than that of the same month on an average of the preceding 18 years.)

Rain... ...	Number of Days	9 rain and 7 dew.	
	Greatest Fall	2·087 inches.	On the 30th.
	Total Fall	2·306 inches.	65 feet above ground.
		2·927 inches.	15 in. above ground.

(Being 0·172 inch greater than that of the same month on an average of the preceding 18 years.)

Evaporation	Total Amount	3·275 inches.	
Ozone ...	Mean Amount	5·7	

(Being 0·6 greater than that in the same month on an average of the preceding 16 years.)

Electricity...	Number of Days Lightning	5	
Cloudy Sky	Mean Amount	3·3	
	Number of Clear Days ...	10	
Meteors ...	Number Observed	8	

Remarks.

Excepting just along the coast, from Sydney northwards, the month has been a very dry one throughout the Colony, and at 38 out of 49 recording stations the fall has been less than one inch of rain, and at many places little or none has fallen; water is running short in many places, and the large rivers falling fast; the Murray is 2 feet 8 inches lower than it was last month at Wentworth. The month has been very mild, and at Sydney the temperature 1·8 above the average. On the 10th, at Sydney, a hot W.N.W. wind came on after 10 p.m.; and on the 15th there was a hot wind from noon until after sunset.

GOVERNMENT OBSERVATORY, SYDNEY.

LATITUDE 33° 51′ 41″; LONGITUDE 10h 4m 46s; MAGNETIC VARIATION 9° 25′ 2″ East.

SEPTEMBER, 1877.—GENERAL ABSTRACT.

Barometer... At 32° Faht.	Highest Reading	30·265 inches on the 14th, at 9·40 a.m.	
	Lowest Reading	29·609 „ on the 20th, at 3 p.m.	
	Mean Height	29·963	

(Being 0·077 inch greater than that in the same month on an average of the preceding 18 years.)

Wind ...	Greatest Pressure	25·2 lbs. on the 23rd.	
	Mean Pressure	0·4 lb.	
	Number of Days Calm ...	0	
	Prevailing Direction ...	W.	

(Prevailing direction during the same month for the preceding 18 years W.)

Temperature	Highest in the Shade ...	76·1	On the 9th.
	Lowest in the Shade ...	43·3	On the 15th.
	Greatest Range	26·2	On the 6th.
	Highest in the Sun ...	136·7	On the 19th.
	Highest in Black Box with Glass Top	183·1	On the 19th.
	Lowest on the Grass ...	37·7	On the 1st.
	Mean Diurnal Range ...	14·4	
	Mean in the Shade ...	58·4	

(Being 0·1 less than that of the same month on an average of the preceding 18 years.)

Humidity ...	Greatest Amount	100·0	On the 11th and 26th.
	Least	43·0	On the 6th.
	Mean	79·3	

(Being 10·4 greater than that of the same month on an average of the preceding 18 years.)

Rain... ...	Number of Days	15 rain and 2 dew.	
	Greatest Fall	1·740 inch. On the 11th.	
	Total Fall	4·845 inches. 65 feet above ground.	
		6·274 inches. 15 in. above ground.	

(Being 3·977 inches greater than that of the same month on an average of the preceding 18 years.)

Evaporation	Total Amount	3·317 inches.	
Ozone ...	Mean Amount	6·0	

(Being 0·7 greater than that in the same month on an average of the preceding 16 years.)

Electricity...	Number of Days Lightning	9	
Cloudy Sky	Mean Amount	5·5	
	Number of Clear Days ...	2	
Meteors ...	Number Observed... ...	2	

Remarks.

The pressure, temperature, and wind this month are very near the average. Moderate rains have fallen at all reporting stations; it was heaviest on the coast south of Sydney, reaching 9·690 inches at Bodalla; along the coast and mountains the quantity ranged from 3 to 9 inches, and inland from 1½ to 3 inches. The rains do not seem to have affected the level of the Darling at Wentworth, and the Murray at the same place has fallen 11 inches since last month. Thunderstorms have been very frequent. Snow was reported from Lake George, Winderradeen Station, on the 14th.

GOVERNMENT OBSERVATORY, SYDNEY.

LATITUDE 33° 51′ 41″; LONGITUDE 10h 4m 46s; MAGNETIC VARIATION 9° 25′ 2″ East.

OCTOBER, 1877.—GENERAL ABSTRACT.

Barometer ... At 32° Faht.	Highest Reading	30·359 inches on the 23rd, at 9 a.m.
	Lowest Reading	29·426 „ on the 19th, at 3 p.m.
	Mean Height	29·891

(Being 0·056 inch greater than that in the same month on an average of the preceding 18 years.)

Wind ...	Greatest Pressure	19·8 lbs. on the 29th.
	Mean Pressure	0·9 lb.
	Number of Days Calm ...	3
	Prevailing Direction ...	S.S.W.

(Prevailing direction during the same month for the preceding 18 years N.E.)

Temperature	Highest in the Shade ...	90·8	On the 27th.
	Lowest in the Shade ...	48·2	On the 22nd.
	Greatest Range	31·5	On the 27th.
	Highest in the Sun ...	147·0	On the 27th.
	Highest in Black Box with Glass Top	198·5	On the 25th.
	Lowest on the Grass ...	41·8	On the 15th.
	Mean Diurnal Range ...	14·9	
	Mean in the Shade... ...	62·4	

(Being 1·2 less than that of the same month on an average of the preceding 18 years.)

Humidity ...	Greatest Amount	100·0	On the 4th and 12th.
	Least	25·0	On the 27th.
	Mean	72·1	

(Being 3·6 greater than that of the same month on an average of the preceding 18 years.)

Rain... ...	Number of Days	14 rain and 3 dew.
	Greatest Fall	4·890 inches. On the 5th.
	Total Fall	6·895 inches. 65 feet above ground.
		8·312 inches. 15 in. above ground.

(Being 5·769 inches greater than that of the same month on an average of the preceding 18 years.)

Evaporation	Total Amount	5·966 inches.
Ozone ...	Mean Amount	6·2

(Being 0·9 greater than that in the same month on an average of the preceding 17 years.)

Electricity...	Number of Days Lightning	9
Cloudy Sky	Mean Amount	5·7
	Number of Clear Days ...	1
Meteors ...	Number Observed... ...	2

Remarks.

Another month of severe drought inland, but along the coast abundant rains have fallen; and at Sydney the amount is 5·769 above the average, greater part of which fell during a storm on the 5th.

GOVERNMENT OBSERVATORY, SYDNEY.

LATITUDE 33° 51′ 41″; LONGITUDE 10h 4m 46s; MAGNETIC VARIATION 9° 25′ 2″ East.

NOVEMBER, 1877.—GENERAL ABSTRACT.

Barometer ... At 32° Faht.	Highest Reading	30·081 inches on the 19th, at 10 a.m.	
	Lowest Reading	29·440 „ on the 2nd, at 2 a.m.	
	Mean Height	29·764	

(Being 0·046 inch less than that in the same month on an average of the preceding 18 years.)

Wind ...	Greatest Pressure	25·2 lbs. on the 1st.	
	Mean Pressure	0·9 lb.	
	Number of Days Calm ...	0	
	Prevailing Direction ...	S.	

(Prevailing direction during the same month for the preceding 18 years S.)

Temperature	Highest in the Shade ...	90·6	On the 1st.
	Lowest in the Shade ...	56·3	On the 5th.
	Greatest Range	27·7	On the 1st.
	Highest in the Sun ...	144·2	On the 2nd.
	Highest in Black Box with Glass Top	196·1	On the 4th and 6th.
	Lowest on the Grass ...	42·2	On the 5th.
	Mean Diurnal Range ...	14·1	
	Mean in the Shade ...	68·2	

(Being 2·2 greater than that of the same month on an average of the preceding 18 years.)

Humidity ...	Greatest Amount	100·0	On the 9th and 10th.
	Least	27·0	On the 1st.
	Mean	70·9	

(Being 1·6 greater than that of the same month on an average of the preceding 18 years.)

Rain... ...	Number of Days	12 rain and 2 dew.
	Greatest Fall	1·088 inch. On the 19th.
	Total Fall	1·604 inch. 65 feet above ground. 2·725 inches. 15 in. above ground.

(Being 0·845 inch less than that of the same month on an average of the preceding 18 years.)

Evaporation	Total Amount	7·339 inches.
Ozone ...	Mean Amount	5·6

(Being 0·5 greater than that in the same month on an average of the preceding 17 years.)

Electricity...	Number of Days Lightning	10
Cloudy Sky...	Mean Amount	5·9
	Number of Clear Days ...	1
Meteors ..	Number Observed	2

Remarks.

The barometer this month has been below the average, but the temperature has been 2·2 greater, and the maximum reached 90·6° on the first of the month, which is very unusual; inland the temperature in many instances has been upwards of 110°. The rainfall on the coast has been moderate, but inland there has been little or none, and the drought is very severe.

GOVERNMENT OBSERVATORY, SYDNEY.

LATITUDE 33° 51′ 41″; LONGITUDE 10h 4m 46s; MAGNETIC VARIATION 9° 25′ 2″ East.

DECEMBER, 1877.—GENERAL ABSTRACT.

Barometer ... At 32° Faht.	Highest Reading	30·114 inches on the 11th, at 10 a.m.
	Lowest Reading	29·204 „ on the 18th, at 6 p.m.
	Mean Height	29·732

(Being 0·020 inch less than that in the same month on an average of the preceding 18 years.)

Wind ...	Greatest Pressure	20·5 lbs. on the 28th.	
	Mean Pressure	1·1 lb.	
	Number of Days Calm ...	0	
	Prevailing Direction ...	E.N.E.	

(Prevailing direction during the same month for the preceding 18 years E.N.E.)

Temperature	Highest in the Shade ...	97·4	On the 23rd.
	Lowest in the Shade ...	55·8	On the 7th.
	Greatest Range	29·6	On the 23rd.
	Highest in the Sun... ...	153·0	On the 23rd.
	Highest in Black Box with Glass Top	213·3	On the 14th.
	Lowest on the Grass ...	50·2	On the 26th.
	Mean Diurnal Range ...	16·5	
	Mean in the Shade... ...	71·6	

(Being 2·1 greater than that of the same month on an average of the preceding 18 years.)

Humidity ...	Greatest Amount	97·7	On the 10th.
	Least	41·0	On the 27th.
	Mean	68·7	

(Being 1·1 greater than that of the same month on an average of the preceding 18 years.)

Rain ...	Number of Days	16 rain and 0 dew.
	Greatest Fall	0·310 inch. On the 10th.
	Total Fall	0·701 inch. 65 feet above ground. 1·461 inch. 15 in. above ground.

(Being 0·746 inch less than that of the same month on an average of the preceding 18 years.)

Evaporation	Total Amount	8·423 inches.
Ozone ...	Mean Amount	5·2

(Being 0·8 greater than that in the same month on an average of the preceding 17 years.)

Electricity...	Number of Days Lightning	10
Cloudy Sky...	Mean Amount	6·6
	Number of Clear Days ...	1
Meteors ...	Number Observed	4

Remarks.

The mean temperature in shade is again 2·1 above the average in Sydney, and generally the heat has been very great. On the coast the rainfall has been considerably below the average, but inland drought still holds sway, and the losses in stock have been very great.

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